Learning to Teach Primary Mathematics: A Case Study

Thesis

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Jean E. Ashfield BA(Hons) MA(Ed)

M1489522

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ABSTRACT

The National Numeracy Strategy (1999), a UK national initiative aimed at raising standards in mathematics, placed considerable emphasis on whole class interactive teaching, as a means to improve teaching and raise levels of attainment. In this research I consider how a group of primary PGCE student teachers, on a one year initial teacher education (ITE) course, developed their understanding and implementation of interactive teaching in mathematics, examining the interplay of personal and contextual influences on their practice as novice teachers.

The two-year study (Sept. 2004 – Dec. 2006) drew on qualitative data from observations, interviews and discussions with students, and later as qualified teachers. Data collected illuminated three issues of particular relevance to the research; students' interpretation of interactive teaching in mathematics; their implementation of this approach; and factors influencing their classroom practice.

Four features emerged as key components of interactive teaching; pupils' active involvement; questioning; discussion; and creative problem-solving. The stage of development, internal factors such as limited mathematics knowledge, low levels of confidence and behaviour management issues, and external factors such as teachers' pre-determined plans, schools' expectations, and Standard Assessment Test targets, were all seen to mitigate against students' use of creative and challenging features of interactive teaching. The role of schools and their mentors emerged as a key factor in students' development from novice to competent teachers, in particular, their use of cognitively challenging aspects of interactive teaching in mathematics.

My study suggests NSS demands for whole-class teaching with pace and urgency, and the Government's insistence on schools meeting ever-higher targets, has driven new teachers back to traditional, didactic teaching of rules and processes, heavily weighted towards SATs questions. This raises questions about the impact ITE might have on students as innovative, creative teachers, if, once qualified, they revert to seemingly safe practice, learned from experienced teachers.

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Abbreviations

BERA	British Educational Research Association
CICADA	Changes in the Curriculum Associated with Discourse and Pedagogy in the Primary School
DCSF	Department for Children, Schools and Families
DES	Department of Education and Science
DfEE	Department for Education and Environment
DfES	Department for Education and Skills
FIAC	Flanders Interaction Categories
GCE	General Certificate of Education
GCSE	General Certificate of Secondary Education
HEI	Higher Education Institute
HMI	Her Majesty's Inspectorate
ITE	Initial Teacher Education
ITT	Initial Teacher Training
IWB	Interactive Whiteboard
NACCCE	National Advisory Committee on Creative and Cultural Education
NNS	National Numeracy Strategy
NLS	National Literacy Strategy
NQT	Newly Qualified Teacher
OfSTED	Office for Standards in Education

OISE/UT	Ontario Institute for Studies in Education, University of Toronto
ORACLE	Observational Research and Classroom Learning Evaluation
PGCE	Post Graduate Certificate in Education
PNS	Primary National Strategy
SAT	Standard Assessment Test
TDA	Training and Development Agency
TIMSS	Third International Mathematics and Science Study
TES	Times Educational Supplement

Research Data References

FG1	Focus Group 1
FG2	Focus Group 2
FPInt	Final Practice Interview
FSInt	First School Placement Interview
FSObs	First School Placement Observation
NTInt	New Teacher Interview
Obs	Observation
PF	Post First School Placement (female)
PM	Post First School Placement (male)
04/F	End of Course (female)
04/M	End of Course (male)

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Introduction

How children learn and develop has been the subject of much interest and research within the last century, increasing our knowledge and understanding about the nature of cognition and learning (Wood 1988; Flavell 1993; Garton 2004). But, as Putnam & Borko (1999) note less attention has centred on teachers, and their role in creating effective learning experiences, notwithstanding Darling-Hammond's view that 'teacher quality is one of the most powerful influences on student achievement' (2000 p.1). Similarly, little attention has been paid to student teachers' experiences of learning to teach, particularly within the current era of reform, prescription and government initiatives in education. In higher education, as Croll and Hastings observe:

> we have paid too little attention to using research evidence on teaching to inform programmes of initial education for new teachers and also paid too little attention to conducting studies which would support the practice of teaching (Croll and Hastings 1996 p.3).

This is a notable omission, for initial teacher education and the experience this provides for students has a strong influence on their effectiveness as teachers and on the likelihood of their remaining in the profession.

These concerns, and Croll & Hastings' plea for more studies that inform and support the practice of teaching, contextualise my research. My intention is to explore the problematic nature of students' professional development as novice teachers, within the complex demands of government initiatives and a standards and target driven profession. My focus is one key government initiative; the National Numeracy Strategy (NNS), introduced into all state primary schools in 1999. Its aim was to raise attainment in mathematics through a prescribed framework of content and methods of teaching mathematics (DfEE 1999). Through my research I aim to provide evidence of students' learning and development as prospective teachers, thus informing and supporting the development of initial teacher education (ITE) programmes.

Furlong et al (2000), addressing the changing role of Higher Education Institutes in ITE, note an increase in central control over the form and content of ITE programmes, and a stronger emphasis on practical, school-based training. Studies such as Furlong's highlight a tension between, what Haggarty (2002) presents as two seemingly opposing views of learning to teach. The first adopts a behaviourist perspective, regarding learning to teach as a training process, whereby curriculum content is standardised and directed, and methods of delivery prescribed, to be practised and delivered by trainee teachers. The emphasis on school-based training and centrally directed initiatives such as the National Literacy and Numeracy Strategies (DfEE 1998 & 1999), suggest this to be the government's view of teacher training, manifested through its agencies; the Department for Education and Employment (DfEE), now the Department for Children, Schools and Families (DCSF), and the Training and Development Agency (TDA).

The second adopts a constructivist perspective, regarding student teachers as active participants in their own learning, able to take a reflective and critical view of their own beliefs and values, past ideas and current initiatives. From this perspective students are regarded as critical analysts of theories of teaching and learning, able to adapt curricular content and teaching approaches in response to their own beliefs and values, their increasing knowledge, and pupils' learning needs (Haggarty 2002). This constructivist view of learning underpins the Post Graduate Certificate of Education (PGCE) course, and the mathematics component that provides the basis for this study.

As mathematics tutor for the PGCE course my particular concern was with students' development as teachers of mathematics, the NNS presenting an apposite focus for study. Within its prescriptive framework, the NNS included a demand for schools to provide a high proportion of direct interactive whole-class teaching, claiming this would lead to higher standards of achievement in mathematics (DfEE 1999). Observations of mathematics teaching during my visits to schools, and anecdotal evidence from school and university colleagues, suggested a great deal of uncertainty about what constituted direct interactive whole-class teaching, and its manifestation in practice. Consequently, there were wide variations in its interpretation and implementation, by both experienced teachers and students. This observation led to my focus on how students came to understand, interpret and implement interactive teaching in mathematics.

Research Setting

My research was set within a South London university ITE provider, and its partnership schools. Participants included 122 prospective primary teachers enrolled in September 2004 on a one year (36 week) primary PGCE course. The course began with six weeks of university-based study, followed by a six-week school placement, further university sessions, twelve weeks' school placement and two final weeks at university.

As primary teachers, students learn to teach all National Curriculum subjects, consequently mathematics was one element of a much wider programme. The taught mathematics component of the course comprised thirteen three-hour workshops with groups of approximately 25 students and the NNS was introduced within this component. Although all students must achieve a minimum Grade 'C' GCSE in mathematics prior to starting an ITE course, their knowledge, confidence and abilities in mathematics vary greatly. The PGCE mathematics programme aimed to develop students' subject and pedagogic knowledge, presenting mathematics in a way that reflected constructivist views of learning and modelled interactive teaching. In the school experience component students worked alongside experienced teachers, furthering their knowledge, understanding and skills and putting their newly formed ideas into practice. Students were observed teaching in those allocated placement schools willing to support my research.

As Course Director, mathematics tutor and school experience tutor, I was fully involved with students at all stages of their programme. The challenge of this dual role of researcher and tutor, and related power and authority issues, inevitably raised questions, which I addressed in planning and carrying out my study.

Research Plan

Two learning communities provided the setting for my study; the university, and partnership schools. My aim was to explore how students' interpretation and implementation of interactive teaching evolved within these communities, during the PGCE course and first year of teaching.

In my Initial Study, a summary of which is provided in Chapter Four, I focused on students' initial experiences, views and beliefs about mathematics, and their interpretation of the interactive nature of direct interactive whole-class teaching. Data from this initial study informed my main study, which addressed students' implementation of interactive teaching, including their use of questioning, discussion, collaborative group work and creative problem-solving, and also aspects of the ITE experience facilitating or inhibiting this.

My focus on students' subjective experiences, and how these are manifested in their actions and responses (Hitchcock & Hughes 1989), draws substantially on qualitative data. Thus, it is situated within the interpretivist paradigm, reflecting the constructivist perspective I adopt throughout the study. Constructivists regard humans as active constructors of their environment whose perceptions of the world are bound by their experiences (Cohen et al 2000), and this reflected the focus of my research questions. I chose to adopt a case-study approach as case studies respond to 'how' and 'why' research questions (Yin 2003), aiming to give a portrayal of a specific situation and identifying the particular features of interaction within it, through 'real people in real situations' (Cohen et al 2000 p.181).

The research developed over two years, charting students' learning journey as novice teachers, through Howell's (1982) stages of unconscious incompetence and conscious incompetence, towards conscious competence as new teachers. Howell's Conscious Competence model *[p.44]* describes the processes and stages of learning new skills, abilities and behaviours and thus models the student teachers' learning journey.

I also took account of Ernest's (1989 p.249) claim that, as students learn to become teachers of mathematics, three key elements combine to determine the kind of teacher they become:

- their mental schemas; their knowledge and beliefs about the nature, teaching and learning of mathematics
- the social context of their teaching environment and the constraints and opportunities experienced
- reflexivity; the level of consciousness of their own beliefs, views and assumptions and the extent to which they reflect on their own practice.

These three elements guided the focus of my study.

Mental Schemas

When students commence the PGCE course they already hold established beliefs, values and assumptions about mathematics based on their experiences of mathematics teaching and learning as pupils, and wider experiences within family and society (Dunne 1993; Pajares 1992). As mature students, usually they will have experienced primary teaching during the 1970s and 1980s, when the Plowden Report (1967) and Cockcroft Report (1982) influenced classroom practice and their views and attitudes to mathematics teaching and learning will have been formed during this time. As Ball (1988) and Calderhead & Robson (1991) observed, these, often negative, views provide the basis for students' interpretations, choices and actions in the classroom. According to Feiman-Nemser (2001), one task of ITE should be to provide students with opportunities to examine these experiences, and challenge the beliefs and assumptions they hold, which otherwise may only become evident in practice. Even then, as Dunne (1993) notes, a teacher's practice may not necessarily represent their underlying beliefs, as the expectations, practices and directives within schools heavily influence practical teaching decisions.

Social Contexts

In a university based ITE course, students, as novice teachers, develop their professional knowledge and practice within the social context of two key learning communities; the university and partnership schools. Within the university setting, through lectures, research, workshops and discussion with peers and tutors, they explore key aspects of teaching and learning, extend their subject knowledge and find their prior views and ideas challenged. Within the social context of partnership schools, they benefit from the knowledge, experience and support of expert teachers, further extending their developing skills, knowledge, understanding and practice as teachers.

These social contexts, as Ernest (1989) observes, have a powerful influence on students' developing identity as teachers. Factors such as the expectations of tutors, peers, teachers and parents, and the curriculum, established practices, systems and ethos within schools all influence the practice students come to adopt. The ways in which these two learning communities influenced PGCE students' interpretation and implementation of interactive teaching became a focus of my study. More specifically, I considered how students began to construct an understanding of interactive teaching and learning in the university context, and the extent to which they integrated key aspects within their teaching of mathematics in school.

Reflexivity

Ernest describes reflexivity as a concern 'to reconcile and integrate classroom practices with beliefs, and to reconcile conflicting beliefs themselves' (Ernest 1989 p.253), advocating it as a key element in learning to teach mathematics. Critical reflection and metacognition, or knowledge concerning one's own cognitive processes (Pintrich 2002) are, as von Glasersfeld (1989) and Hart (2000) note, integral to the interactive process of teaching and learning. I considered critical reflection fundamental in supporting students' learning and their understanding and implementation of interactive teaching in mathematics.

The constructivist view, which I believe underpins the PGCE mathematics programme, places scaffolding at the centre of interactive teaching and learning, for students, and the pupils they teach. An interactive approach views learning and the construction of knowledge as a shared and active endeavour, the teacher or more knowledgeable other, providing supportive and sensitive intervention, enabling the learner to achieve more than would be possible alone (Vygotsky 1978; Mercer 1995; Bruner 1996). Thus, I considered reflection, metacognition and scaffolding key elements of the students' learning experience.

I have integrated Ernest's key elements within Howell's model of conscious competence to provide the framework for my model of learning *[p.43]*. This shows the interplay of the student as an individual learner, within the social contexts of university and partnership schools.

My research began with an Initial Study, exploring students' experiences of learning mathematics and their developing understanding of interactive teaching. Data were obtained through an open question presented to all 122 students and follow-up interviews with a smaller group. Further data were obtained from university-based mathematics sessions and students' initial observations of mathematics teaching in schools. My main study focused on this smaller group and their implementation of interactive teaching in school.

Participants

A sample group of twelve students from the cohort of 122 was involved in the main study. These are detailed below with pseudonyms used throughout the study.

Sample Group

Age band	Female	Male
21-30	Nell, Saba, Hiby, Rhea,	Jared, Simon
31-40	Carla, Lise,	Paul, Harry
41-50	Mags,	Freddie

Fig.1

Data were obtained from my observations of the students' teaching and follow-up interviews, during the two school placements (Nov.2004; April/June 2005). Observations focused on students' use of interactive teaching, in particular their use of discussion, questioning, and collaborative, creative problem-solving and follow-up interviews encouraged students to reflect on their use of these features. Field notes from observations and interviews provided data for analysis in the first school placement. In the later placement, data were collected from videotaped lessons and recordings of follow-up discussions and interviews.

The final part of the study took place in November 2006, a year after students had completed their first year as qualified teachers. This entailed observations and/or interviews with four of the sample group of students at the beginning of their second year of teaching. Observations were videotaped and teachers' implementation of key features of interactive teaching explored through semi-structured interviews.

Data Analysis

Qualitative researchers often take a linear approach of data gathering followed by analysis and subsequent reflection (Charmaz 2006). However Miles & Huberman (1994 p.50) advise an alternative approach that entails 'interweaving data collection and analysis from the start', making analysis a continuous, dynamic process. This enables the researcher to consider data collected early in the study and use it to inform further data collection as the study progresses. I considered this integrated approach to data collection and analysis, appropriate for an extended study, as questions could be amended, ways of recording varied, or data collection adjusted as ideas became more clearly focused.

Development of the Mathematics Curriculum

The NNS is the most recent initiative within a cycle of reforms in mathematics education. This cycle has seen recurrent demands for a less utilitarian view of mathematics, one focused on developing mathematical understanding and creative problem-solving, set alongside seemingly opposing demands for improved test and examination results. In this section, I take a brief look at this cycle of reform as it contextualises the NNS approach to teaching and learning mathematics, provides the context for this research and also my focus on interactive teaching.

Political concerns regarding educational standards, particularly mathematics, were a driving force in the conception of a nationally agreed curriculum for schools, an idea heralded in Prime Minister James Callaghan's 'Great Debate' speech in 1976. The first version of this National Curriculum appeared in 1989, and a revised version (2000) provides the current mathematics curriculum for all state schools in England and Wales. There has been a long history of such concerns; from the inception of state-funded education, perceived low standards in basic arithmetic and problem-solving have drawn criticism, as evidenced in inspectors' reports since 1858 (Howson 1982). Employers also expressed concerns, critical of poor levels of numeracy and problem-solving abilities among school leavers (Hughes et al 2000). Nevertheless, despite many changes in education during that time, little evidence of improved standards was noted (Howson 1982).

Continued pressure from employers ensured utilitarian reasons for teaching mathematics predominated, accompanied by regulatory testing. This led to concerns that education in England had become dominated by examinations, and teachers focused on teaching only what examiners demanded. As Howson (1982) observed, there appeared to be little consideration given to developing pupils' understanding or application in mathematics, aspects he noted that were more difficult to test.

Reforms in Mathematics Education

This became a recurrent theme in subsequent reports and reforms in mathematics education, as the Hadow Report in 1931, The Plowden Report of 1967 and The Cockcroft Report in 1982, illustrate. The Hadow Report advocated 'more vivid, more logical and more practical methods in teaching the subject, methods which will cause the pupil to appreciate both the beauty of mathematical truths and the practical application' (Howson 1982 p.185). Pupils, it was claimed, needed to master, not only basic mathematical skills and procedures, but also understand the mathematical concepts underlying these, in order to apply their knowledge in new contexts and solve problems. As Howson observes:

> understanding must precede drill or formal exercises intended to develop memory, mechanical accuracy or speed... Practice without the power of mathematical thinking leads nowhere; the power of mathematical thinking without practice is like knowing what to do but not having the skills or tools to do it (Howson 1982 p.196).

Nonetheless, he noted, that with the continued focus on testing, there was little impact on practice within schools where teaching rules and procedures predominated.

The Plowden report (1967) and the Cockcroft Report (1982) both similarly called for less mechanistic approaches and a stronger focus on developing children's mathematical understanding through discussion, practical work, problem-solving and investigational work. Cockcroft advocated 'discussion between teacher and pupils and between pupils themselves as an essential feature of mathematics lessons at every level' (Cockcroft 1982 para. 243), and problem-solving as 'the heart of mathematics' (para. 249). Nevertheless, regulatory testing based on recall of facts and procedures persisted, and schools found it difficult to give attention to, more cognitively demanding aspects of mathematics. With results showing little apparent improvement in mathematics' standards, concerns remained.

There appear to be competing perspectives at play in this debate. The formalist, traditional view of mathematics, tending to favour rules and procedures, challenged by the dynamic view of mathematics as intuitive, active, collaborative, creative and investigational, and knowledge as constructed by learners through meaningful learning experiences (Ernest 1989 & 1994; Lerman 1996). Plowden (1967) and Cockcroft's (1982) reports appear to reflect the latter, constructivist view of learners, as active creators of their own knowledge, socially constructed through dialogue, reflection and discussion, and able to respond confidently to novel problems (McGuiness 1999). Continued requirements to monitor attainment through testing however, ensured the formalist view prevailed, and teaching rules and procedures predominated over development of deeper understanding, difficult to assess through such testing. As Howson (1982) notes, the government perceive higher test results to be evidence of improved standards and enable comparison of school performance. It seems that, while test scores remain the measure of teachers' and schools' effectiveness, and such tests focus on the recall of facts, basic skills and procedures, the development of pupils' deeper mathematical understanding and application in solving novel problems will remain lost in the drive to achieve good test results.

Although employers continued to voice concerns over school leavers' standards of mathematics, it was England's position in international league tables such as the International Mathematics and Science Studies (TIMSS 1995; Kelly 2002) that made headline news. The poor performance in mathematics of several western countries including England, led to further criticism of mathematics teaching and a 'back to basics' call from the government (Reynolds & Farrell 1996). Teachers were held responsible for this poor performance, once again finding themselves under pressure to meet competing demands. Schön's comments made in 1983 resonate:

> teachers are faced with pressures for increased efficiency in the context of contracting budgets, demands that they rigorously "teach the basics," exhortations to encourage creativity, build citizenship, help students to examine their values (Schön 1983 p.17).

This demand for a back-to-basics approach suggests a backward rather than forward-looking view of mathematics education. Such a narrow focus on testable, knowledge-based skills has significance for those aware of current fast-paced technological development and the need to address the requirements of a new 'knowledge society' (Hargreaves 2003), where knowledge is shared, created and developed within creative learning communities. This, Hargreaves suggests, requires a different kind of teaching and a different kind of teacher, one who can foster the creativity, flexibility, problem-solving, risk-taking and collaboration expected of young people. As Fisher (1987) urges, providing opportunities for children to experience real problem-solving activities builds their confidence and ability to solve the kind of problems they will face in this fast changing world. Recognising the significance of this for a future generation of teachers, reaffirmed for me the importance of developing students' understanding of creative, investigative problem-solving, and collaborative, interactive approaches to teaching and learning in mathematics. Nevertheless, these characteristics continue to be disregarded in government initiatives, where teachers are required to comply with teacher-directed approaches, focus on getting through a prescribed curriculum, and prepare pupils for the constant demand of testing and meeting national targets.

Development of the National Numeracy Strategy

Publication of the TIMSS results (Kelly 2002) and associated 'World's Apart' report (Reynolds & Farrell 1996) prompted the government to establish a 'Numeracy Task Force', tasked with uncovering the reasons for England's poor results in mathematics. The Task Force found direct whole-class teaching to be a common feature of mathematics lessons in top attaining countries and singled this out as the proven key to raising standards (Reynolds & Farrell 1996). Direct interactive whole-class teaching hence became the key feature of their new National Numeracy Strategy (NNS) (DfEE 1998b *para 21).* Although promulgating more direct whole-class teaching, this, it was claimed, did not refer to formal 'chalk and talk' or 'drill and practice' teaching (DfEE 1998b p.14), instead inclusion of the term interactive was to suggest a more active process that fully involved the pupils. This offered a glimmer of hope that perhaps now an active, collaborative and creative approach to learning mathematics might be developed.

This was not to be however, instead the Numeracy Task Force's reports (DfEE 1998a, DfEE 1998b) presented a heavily prescribed structure for teaching mathematics. All schools were expected to provide daily mathematics lessons of 45-60 minutes duration with a clear three-part structure; 5-10 minutes oral/mental work, a 40 minute main teaching section and a 10 minute plenary (DfEE 1998b para. 21*)*. There was a marked focus on quick recall of number facts in the short 'oral and mental' phase and emphasis placed on, 'good direct teaching that is lively and stimulating' for the main part of the lesson (DfEE 1998b para. 23). National targets requiring 75% of 11 year olds to achieve the 'standard expected for their age in mathematics' by 2002 (DfEE 1998a p.4) were set, with virtually all children expected to achieve this by 2007 (DfEE 1998b p10 para. 12). Yet again, testing was to drive the curriculum, with teachers inevitably focusing their teaching on these tests. Opportunities for pupils to develop deeper mathematical understanding and creative problem-solving through discussion, collaborative and investigational activities appeared to have been neglected yet again.

Although all teachers in England's state primary schools received cascaded training in the NNS prescribed methods of teaching mathematics, how they interpreted and implemented these methods varied a great deal as Moyles et al (2003) and Smith et al (2004) found through their research. PGCE students, whilst building their knowledge and understanding of direct interactive whole-class teaching, would be working alongside experienced teachers in their classrooms and were likely to model their practice on the teachers they observed (Putnam & Borko 1999; Maynard 2001). This raised particular issues of interest for my study, discussed in the next chapter.

ITE providers were required by the DfEE to ensure students adopted the NNS and its particular approach to teaching mathematics and delivered its framework in the prescribed way, within every primary year group (DfEE 1998a). There was no suggestion they should consider and critically examine different approaches, instead they were expected to be unquestioning deliverers of a prescribed curriculum, using specified methods provided in the NNS guidance (DfEE 1999). The implication was that, rather than educating thoughtful, analytic and evaluative students able to make considered choices, ITE providers should be training, what Edwards & Protheroe (2003 p.228) describe as, 'deliverers of a curriculum...at the expense of a focus on responsive and interactive pedagogy'. The Training and Development Agency's (TDA) current inclination to refer to initial teacher education as Initial Teacher Training (ITT) and students as 'trainees' reflects this view. Csikszentmihalyi claims one of the unfortunate effects of the kind of standardised content outlined in the NNS is, 'the depreciation of the role of teacher to that of information technician' (1993 p.177), rather than knowledgeable professionals able to make critical, analytical and informed judgements about teaching and learning (Frowe 2005). Goodson similarly argues such standardisation replaces teachers' professionalism 'with notions of the teacher as the technical deliverer of guidelines and schemes devised elsewhere' (Goodson 2003 p.126). Like most initial teacher educators, I see my role as developing reflective, analytic and evaluative teachers, able to examine new initiatives such as the NNS, and their own developing practice critically (Haggarty 2002).

Inevitably, government directives that require ITE providers to *train* students to deliver this prescriptive, knowledge-based framework with its pre-determined expectations and outcomes, unquestioningly and in their specified way, create dissonance for those engaged in ITE. Encouraging students to develop lively, interactive and creative teaching and learning, within this seemingly mechanistic, tightly structured and directed strategy, presented a challenge for me as mathematics tutor. One, seemingly reflected in a later government publication; 'Excellence and Enjoyment' (DfES 2003a) that claimed:

> Good learning and teaching should make learning vivid and real; developing understanding through enquiry, creativity ... and group problem solving *[and]* make learning an enjoyable and challenging experience (p. 29).

Government initiatives which suggest a view of learning that, 'focuses on content over process, comprehension over competence, ability over engagement, teaching over self-discovery' (Claxton 1999 p.121), are not likely to achieve this aim, nor will they prepare teachers to educate pupils for the world currently evolving. Within mathematics education, repeated calls over the last century for pupils to develop understanding in mathematics, to be able to apply this knowledge in new situations and to be creative in solving problems (Biggs 1972; Skemp 1976; Mason, Burton and Stacey, 1982; Cockcroft 1982), suggest this remains an ongoing concern.

Regulatory Testing: Standard Assessment Tests

Standard assessment tests (SATs) were introduced with the National Curriculum in 1989 as a means to monitor standards in mathematics and ensure teachers were held accountable for children's attainment and performance. Since the introduction of the NNS national targets and league tables have placed further pressure on teachers and pupils to meet prescribed standards, resulting, as Harlen et al (2002) point out, in an over-emphasis on revision and rote-learning in order that pupils perform well. Although the target for 75% of 11 year olds to achieve the 'standard expected for their age in mathematics' by 2002 (DfEE 1998a p.4) was not met, results suggested the NNS approach, and an increased focus on numeracy, had a positive effect, at least on those aspects of mathematics tested through SATs. Nevertheless, as Brown et al (1998) point out, and Peterson (1988) had found ten years previously, although more traditional whole-class teaching produced slightly better performance in achievement tests such as SATs, worse results tended to be obtained in tests of more abstract thinking such as creativity and problem-solving. This concentration on 'testable' skills and knowledge fuelled concerns that assessment or 'testing' had become a more important focus for schools than the learning these tests supposedly represented, Thompson (2001) pointing out that:

> when academic progress is judged by a single indicator and when high stakes...are attached to that single indicator, the common effect is to narrow curriculum and reduce instruction to test prepping (Thompson 2001 p.358).

Teachers confirmed these concerns: 'Oh their scores are better – certainly they're better. But do the children know any more? No. It's because we've taught them how to jump through hoops' (OISE/UT 2001 p.72). Ruthven's play on a familiar phrase seems apposite; 'what you test is what you get' (1993 p. 433). Teachers clearly felt under pressure to teach facts and skills enabling pupils to answer SAT questions, at the expense of developing their understanding and creative problem-solving abilities and this became evident during my study where students found themselves under similar pressures. As Peterson (1988) reminds us, although memorising facts and procedures may help children succeed in standardised tests, it fails to provide them with the ability to think or communicate mathematically, or adequately prepare them for the world of tomorrow where they will be required to apply knowledge and understanding creatively to solve novel problems (Hargreaves 2003).

The PGCE mathematics programme

As Haggarty (2002) points out, students join primary ITE courses, not as blank canvasses primed for imprinting with approved models of teaching, but with previously acquired images of teaching drawn from their own experiences as pupils. These inform how they see themselves, and shape their views of what they need to learn in preparation for teaching. The PGCE course aimed to provide students with opportunities to reflect on their experiences of mathematics, examine the NNS approach and their own developing practice, and discuss and critically question these in relation to theory, context and their own beliefs and values.

Students were introduced to the NNS and to direct whole-class interactive teaching through the core mathematics module (*App.13*). They observed this approach in schools and implemented it themselves during school placements. For the majority of students it was an unfamiliar way of teaching mathematics, often very different to that experienced as pupils, which they described as a whole-class didactic chalk-and-talk approach. This was the view students shared at the beginning of the course, and one likely to have, as Goodman (1986), Ball (1988) and Calderhead (1988) suggest, a powerful influence on their views of teaching and of themselves as teachers.

The university mathematics tutors adopted an approach based on constructivist views of teaching and learning (Vygotsky 1978; von Glasersfeld 1995). Students were encouraged to construct their own knowledge and understanding of mathematics teaching and learning through scaffolded learning that included interaction with peers and tutors, and interaction of their prior knowledge with new knowledge developed in university sessions and school placements (Bruner 1986; Winitzky and Kauchak 1997). Pair, group and whole-class discussion, and collaborative activity formed key elements of the course programme, thus modelling the socio-constructivist view embedded within interactive teaching (Vygotsky 1978).

The inclusion of the term 'interactive' in the NNS framework had suggested a more active, collaborative approach to learning mathematics. One which incorporated Askew et al's (1997) and Brown et al's (1998) key features of effective teaching and learning in mathematics; the setting of challenging tasks, which require children to think, explain and discuss their ideas; collaborative problem-solving that develops creative thinking, and the use of higher-order questioning. My previous observations of students' mathematics teaching during school placements, and anecdotal evidence from school and university colleagues, had suggested that interactive whole-class teaching was rarely interpreted in this way. Rather, a teacher-directed, knowledge-transmission approach predominated, with these key features of effective teaching rarely evident. Interpretation and implementation of interactive whole-class teaching by both experienced and prospective teachers seemed to indicate a great deal of uncertainty, which prompted my focus for this research.

My aim was to explore the seeming battle between utilitarian values, usually held by teachers who were constrained by government policy focused on quantifiable results, and a more enlightened view of learning, often held by students themselves and by ITE tutors. More specifically, I wanted to explore how students' interpretation and implementation of interactive whole-class teaching evolved during their PGCE course and in their first year of teaching, focusing in particular on their use of features of effective teaching; questioning, discussion and collaborative, creative problem-solving.

It was my intention that this study would inform my own practice and future course development. Also, by providing an advanced understanding of how students learn to teach mathematics within a restrictive standards and target-driven environment, where little research currently exists, it would add to research on mathematics education and the initial education of primary teachers.

This chapter has introduced the background to the study, outlining the context within which it is set and the reform cycle, of which the National Numeracy Strategy forms a part. In Chapter Two I consider current research that has informed and guided this research. In Chapter Three the methods adopted are outlined, and in Chapter Four I analyse and discuss my findings. In the final chapter I offer an evaluation of the study and consider its implications for mathematics education and research.

2

Literature Review

In the first section of this chapter I address the NNS and its implementation in schools and explore key features of interactive teaching in mathematics. I draw, in particular, on research by Moyles et al (2003), focusing on teachers' implementation of interactive teaching within the National Literacy Strategy, and Smith et al's (2004) and Burns & Myhill's (2004) research on teacher discourse, within both National Strategies.

In the second section, I provide a brief consideration of the physical and social learning contexts, within which students' experience of learning to teach takes place, with reference to Lave & Wenger's (1991) idea of communities of practice. I introduce a diagrammatic representation of the social context of learning that provides the lens through which I see students' development as teachers of mathematics, and how they interpret and implement interactive teaching.

The National Numeracy Strategy: Theory and Practice

As has been shown *[p.13]*, reforms over the last century have called for a focus on developing pupils' mathematical understanding, creativity and problem-solving skills, through their active engagement in discussion and collaborative, investigative activities. The extent to which the NNS reflects these concerns remains open to question. The NNS advocates direct interactive whole-class teaching for a substantial part of every mathematics session, emphasising 'good direct teaching that is lively and stimulating' (DfEE 1998b, para. 23). Critics argue that there is no clear definition and little practical guidance for teachers on the interactive aspect of this approach (Brown et al 1998; Moyles et al 2003; Smith et al 2004; Burns & Myhill 2004). Indeed, as Galton et al (1999b) claim, there is little evidence available to suggest that in practice this approach has differed in any substantial way from the traditional whole-class teaching reported in earlier studies of primary teaching (Mortimore et al 1988; Pollard et al, 1994). There is some suggestion of children's active engagement, in the NNS description of direct interactive whole-class teaching, as 'a two-way process in which pupils are expected to take an active part by answering questions, contributing points to discussions and explaining and demonstrating their methods to the class' (DfEE 1999 p.11). There is also passing reference to pupils spending some time in groups and pairs where they can 'collaborate in solving a problem and keep their skills sharp through a variety of well paced activities' (DfEE 1998b). Certainly any clear pedagogical rationale or theory supporting direct, interactive whole-class teaching is absent from Task Force reports and, as Brown et al (1998) and Moyles et al (2003) assert, little research evidence is presented that underpins its recommendations. Additionally, Costello (2000) points out, this focus on one specific teaching approach ignores differences in pupils' cognitive styles. This raises questions for student teachers, urged to take account of, and respond to, children's different interests, needs and learning styles, and their individual prior knowledge and understanding.

Although my focus in this study is students' interpretation and implementation of the interactive element of direct interactive whole-class teaching, all elements need to be considered in order to fully understand and interpret this approach. These are discussed in the following section.

Direct whole-class teaching

The Numeracy Task Force presented direct instruction, through a majority of whole-class teaching, as the key to raising numeracy standards, claiming support from inspection evidence, research, and data from more successful countries. Reynolds & Farrell note in their Preliminary Report:

> Some of the countries that do best in international comparisons, such as Japan and Korea, report a high frequency of lessons in which children work together as a class, and respond to one another (DfEE 1998a para 42 p.19).

Alexander (2004b) challenged these claims, suggesting they drew inappropriate correlations between the practice of whole-class teaching and educational outcomes; that as, 'direct instruction through whole class teaching is the commonest teaching approach world-wide so it is as strongly associated with low standards as with high' (Alexander 2004b, p.17). Although some research studies (Rosenshine, 1971; Galton & Croll, 1980; Burghes 1995; Bierhoff & Prais 1995; Bierhoff 1996) would seem to support the Task Force view, Brown et al (1998) argue that evidence for the effectiveness of whole-class teaching is questionable. Positive association between attainment and whole-class teaching they note, related to high quality interactions rather than to whole-class teaching per se, claiming poorer quality whole-class teaching produced the lowest results (Brown *et al* 1998; Alexander 2004a; 2004b). The Task Force did acknowledge this in its assertion that it was not whole-class teaching alone, but the quality of interaction, that was of prime importance (DfEE 1998a).

According to the NNS Framework direct teaching includes: 'directing, instructing, demonstrating, explaining and illustrating, questioning and discussing, consolidating, evaluating pupils' responses, summarising' (1999 p.11/12). Most of these features focus on delivery of content to a whole class, all, as Brown notes, under 'the firm control of the teacher' (Brown 1999 p.9). Despite rhetoric within the NNS, this suggests a didactic, knowledge-transmission approach, regardless of NNS expectations of pupils as active learners (DfEE 1999). According to Muijs & Reynolds, this is a behaviourist approach, which views learning as taking place through conditioning, reinforced through extrinsic rewards. It is, they claim, 'clearly connected to the 'teaching a small step-practice-review' model used in direct instruction' (Muijs & Reynolds 2001 p. 8), and is an effective method of teaching rules, procedures and basic skills. As Brophy & Good (1986); Peterson (1988); Orton & Frobisher (1996) and Muijs & Reynolds (2001) argue, this may be helpful for performing well in SATs, where most mathematics questions rely on recall of facts and procedures, with little attention given to pupils' mathematical understanding and application (OfSTED 2008). Nevertheless, it tends to encourage passive and overly dependent pupils and is not perhaps the panacea suggested by the Numeracy Task Force

(1998a), Desforges warning 'it is never on its own sufficient to ensure deeper understanding, problem solving, creativity or group work capabilities' (Desforges 1995 p.129). Indeed, as Muijs & Reynolds (2001) have observed, it is possible for teachers to use effective direct teaching strategies to teach undemanding and unchallenging content, which '... can degenerate into ... lessons with little interaction with students' (Muijs & Reynolds 2001 p.15). This raises concern that student teachers, in their observations of teachers in school may witness such ineffective lecture-style lessons.

Although the Numeracy Task Force claimed their recommendations were not advocating a return to the traditional, didactic, chalk-and-talk method, whole-class approaches had been associated with this formal, didactic style of teaching, as previous studies of the effect of different teaching styles on pupil progress, notably Bennett (1976) have shown. One of the earliest and oft quoted is the ORACLE (Observational Research and Classroom Learning Evaluation) project (Galton & Croll 1980), replicated in a follow-up study by Galton et al (1999a), and similar studies by Mortimore (1988) and Pollard et al (1994). Data from the ORACLE Project showed the success of whole-class teaching was determined by the quality of teaching. High quality teaching, as Mortimore (1988) notes, includes the use of higher-order questions, frequent questioning and involvement of pupils, and collaborative problem-solving. These are aspects that, as noted in Chapter One, previous mathematics reforms have called for repeatedly, and indeed the Numeracy Task Force recommended in its Preliminary Report (DfEE 1998a). Nevertheless, Galton's findings showed the majority of whole-class teaching time taken up by teachers' factual or procedural statements, or by the setting of cognitively 'low level' problems. As he explains:

> the shift to whole-class teaching has largely been taken up in absolute terms by an increase in the amount of talking **at** pupils through statements and not in talking **with** pupils by asking questions (Galton et al 1999 p27).

Similar studies, such as PRINDEP (1986-91) and CICADA (1990-92) supported Galton et al's findings. Similarly, Scheerens & Creemers (1996) in reviewing Dutch research, found a positive relationship between whole-class teaching and pupil outcomes in only three out of twenty-nine studies (Reynolds & Muijs 1999). Such findings must raise doubts about the Task Force's claims for the effectiveness of direct whole-class teaching.

HMI also expressed concerns about teachers' tendency to adopt a didactic approach, noting a predominance of teachers' talk and failure to obtain 'a judicious balance between timely demonstration, instruction and explanation on the one hand, and pupils' collaboration, discussion or independent work on the other' (OfSTED 2003 p.22). Far from supporting the claim that an increase in direct whole-class teaching would raise standards in numeracy, the OfSTED report suggests direct whole-class teaching, although it may increase the amount of interaction between teacher and pupils (DfEE 1998a), has not led to more effective or higher-level interaction that furthers children's mathematical understanding. It appears the need to develop mathematical understanding through discussion and creative problem-solving (Cockcroft 1982) is still to be addressed. My study was thus directed towards students' interpretation, and hence implementation, of interactive whole-class teaching and learning in mathematics, and the need for students to adopt a critical, informed view of this, rather than be presented with the NNS in the didactic, unquestioning way it was introduced to teachers.

Interactive Teaching

Whole-class teaching was acclaimed, 'an effective and efficient way of maximizing the amount of interaction between the teacher and all the pupils' (DfEE 1998a p.19). As Croll & Hastings (1996) and Black & Wiliam (1998) note, interaction is intrinsic in all teaching and learning, the primary classroom pre-NNS thus already being an overwhelmingly interactive environment. Yet the government, in highlighting direct interactive whole-class teaching as a new and important approach, suggested it to be a novel and innovative way of teaching (Alexander 2000). The term 'interaction' is perhaps too all-encompassing and, as Myhill suggests, 'does not adequately describe or reflect the multifaceted ways in which talk can play out in the classroom' (Myhill 2006 p.20).

It is not clear what is novel in the NNS view of interactive teaching and its manifestation in practice, as NNS materials provide very little information and little research evidence is presented to support the recommendations made, as Brown et al (1998), Moyles et al (2003) and Myhill (2006) observe. Although it seems a laudable aim to maximize the contact between teacher and pupils this does not in itself ensure the contact will be beneficial in developing learning. Alexander points out, 'the quality of a teacher's work-related interactions is not necessarily defined by their number' (Alexander 2000 p.395). Improving the quality of interaction rather than the quantity therefore seemed essential, with students having an informed view of what denotes quality interaction, in order to implement this approach.

Interactive teaching and learning has at its root a constructivist view, with pupils actively engaged with their learning, creating their own knowledge and understanding through experience and interaction with their environment and other people. Its origins may be traced back to the 18th century and the writings of Kant, but is more readily associated with Piaget, whose views of learning greatly influenced the Plowden Report (1967). Von Glasersfeld (1995), developing this perspective, advocated a more specific role for teachers in guiding learning, than the facilitative role Piaget seemed to have suggested. As he observed, although concepts are built up individually by each learner, 'teachers have the task of orienting the student's constructive process' (von Glasersfeld 1995, p.186). Continuing a familiar argument, Von Glasersfeld professed teaching to be about understanding, rather than just learning facts, noting:

> Teaching has to be concerned with *understanding* rather than performance and the rote learning of, say, the multiplication table, or training the mechanical performance of algorithms – because *training* is suitable only for animals whom one does not credit with a thinking mind (von Glasersfeld 1994 p.7).

He dismissed a didactic approach, considering teaching had 'little to do with the traffic of knowledge,' but rather was 'to foster the art of learning' (von Glasersfeld 1995 p.192), and required the learner's active engagement. Such an individualised approach, exemplified in Plowden's classrooms, came under much criticism and at the time was cited as a key reason for Britain's falling standards (Bennett 1976; Croll and Hastings 1996; Muijs and Reynolds 2001; HMI OfSTED 2003). Interestingly, the DfES in the Primary National Strategy (PNS) appears to return to this approach, asserting, 'learning must be focused on individual pupils' needs and abilities' (DfES 2003a p.39). Social constructivists, Vygotsky and Bruner, further emphasised the integral role of both teacher and pupils in the learning process, regarding learning as both socially and culturally derived (Pollard 2002). Vygotsky's claim that 'a child's potential for learning is revealed and indeed is often realised in interaction with more knowledgeable others' (Vygotsky 1978 p.26), reaffirmed the importance of talk in children's learning and saw the teacher adopting an active, interventionist stance rather than the facilitative role proffered by Piaget (Orton & Frobisher 1996). The role of the teacher was to scaffold learning, a term introduced by Bruner (1985) to describe support that enables the learner 'to achieve heights that they cannot scale alone' (Wood, 1998 p.80). The learner is not simply a passive recipient but shares in the construction of new knowledge through social interaction. Social interaction thus plays a key role in learning and the NNS *appears* to promote this with its use of the term interaction. However, it is difficult to set this alongside the behaviourist approach of direct whole-class teaching that seems to prevail. Certainly there was no clear guidance on effective interaction in the NNS documentation and training, although supporting materials sent to schools (NNS1999) did include videos of exemplar whole-class lessons, modelling what the NNS considered 'oral, interactive and lively' teaching. Disappointingly, closed, teacher-directed, fast-paced questions dominated, with little evidence of pupil/pupil discussion or of teachers scaffolding learning. There was little indication or explanation of how pupils' understanding was being furthered or challenged, or what specific features illustrated 'high quality' interactions.

Several studies have explored teachers' interpretation and implementation of interactive teaching in mathematics and Literacy. Moyles' et al (2003) focused on literacy, whilst Smith et al (2004) and Burns & Myhill (2004) considered both Literacy and Numeracy. The lack of specific guidance, in both the NNS and the NLS, and consequent diverse practice within schools, featured in all three studies. Moyles et al (2003) report that, despite their NLS training, two thirds of teachers interviewed still felt uncertain and confused about what interactive teaching was, thus, with little clear exposition of interactive teaching in directive materials, formed their own, diverse, interpretations. Finding no shared understanding of interactive teaching between teachers, Moyles et al moved away from their original aim of trying to identify one common model and eventually settled on outlining 'a repertoire of effective practice' (Moyles et al 2003 p.174). New teachers entering the profession therefore have no clear guidance from the NNS, and rely on the diverse interpretation and practice of teachers in schools who provide the role model for their practice. This leaves open to question the guidance and support students would receive in coming to understand interactive teaching; either from the practice they observed in schools, or through their discussions with teachers and mentors.

Smith et al (2004) focused their study on the discourse used by primary teachers, using computerized systematic classroom observation, primarily the Initiation-Response-Feedback (IRF) structure identified by Sinclair & Coulthard (1975), to record exchanges. Video recordings were used to identify types of questions used and length of pupil utterances, whilst teachers' understanding of the concept of interactive whole-class teaching was explored through questionnaires. Burns & Myhill (2004) focused on the interactive nature of whole-class teaching, drawing on data collected by three headteachers of whole-class teaching in their schools. As in Moyles et al's (2003) research, Smith et al's (2004) and Burns & Myhill's (2004) findings suggested the national strategies had not dramatically changed traditional patterns of whole-class interaction. Teachers spent the majority of their time either explaining or using highly structured question and answer sequences requiring lower cognitive engagement and, as Burns & Myhill report, controlled the knowledge 'in an inflexible, authoritative manner' (2004 p.45). Responses to Smith et al's (2004) questionnaire also confirmed Moyles' (2003) findings that teachers had not established a clear concept of interactive whole-class teaching.

The approach adopted by Smith et al (2004) and, to a lesser extent, Moyles et al (2003) and Burns & Myhill (2004), was to quantify classroom interactions through the use of pre-coded categories. Such an approach enabled consideration of a large number of events and generalisation from the analysis of large amounts of data. This method of observation, which focuses on pre-determined, specific types of behaviour, may miss the 'thick' description valued in ethnographic studies. Hence I made the decision not to adopt this approach for my study, focusing instead on students' own interpretations and perceptions of their practice.

These three studies focused on practising teachers and their interpretation and implementation of interactive teaching from the NLS/NNS. Although there are several studies that address student teachers' learning and teaching of mathematics (Thompson 1984; Ball 1988; McNamara 1991; Calderhead & Robson 1991; Brown et al 1999), I found no research focusing specifically on students' evolving interpretation and implementation of interactive teaching in mathematics, and my study aims to fill this gap. Consideration of what 'interactive teaching' may be in practice has perhaps presented more questions than answers. These research studies show varied practice in schools, with most teachers tending towards a didactic, curriculum-driven model of teaching. Much research and discussion of direct interactive whole-class teaching has focused on the role of the teacher with little consideration given in the NNS to children's development as creative mathematical thinkers. Within the PGCE course this was a key concern, both for the development of students as mathematical thinkers themselves and for the pupils they would teach. If students were to be prepared for teaching in the knowledge society of the 21st century they would need to develop their own, and pupils', creativity, flexibility, problem-solving, risk-taking and collaboration (Hargreaves 2003), thus avoiding unquestioning compliance with models of teaching currently presented in schools.

Key features of interactive teaching

Research (Askew et al 1997; Muijs & Reynolds 2001) has given a clear indication of factors that promote effective learning and teaching of mathematics. These include the development of creative, higher-level thinking through collaborative problem-solving, involving the use of higher-order questioning and discussion, and the setting of challenging open-ended tasks, requiring pupils to think, then explain and discuss their ideas (Peterson 1988; Askew et al 1997; Brown et al 1998; Jones, Tanner & Treadaway 2000). These factors of effective teaching became a focus for students' developing knowledge and understanding of mathematics teaching, and came to be seen as key features of interactive teaching, thus informing their interpretation and implementation within the classroom. My observations and discussions of students' practice in school consequently focused on these aspects, which are addressed further in the following section.

Questioning

Questioning has been identified as one of the most important elements of effective teaching, (Mortimore et al, 1988; Croll & Hastings, 1996; Muijs & Reynolds, 1999; Jones et al, 2000), although who poses the questions, the purpose of those questions and the cognitive demand they make on pupils, varies greatly. Acknowledging this, Reynolds & Farrell (1996) and Burns & Myhill (2004) focus almost entirely on teacher questioning in their analysis of interactive teaching. Burns & Myhill (2004) note that teacher-led questioning and explanation dominate classroom interaction, the majority of teachers' questions tending to centre on general management and organization, which demand very little cognitive engagement from pupils. They recorded 64% of teacher questioning as factual elicitation and a further 8% concerned with class and task management. Wragg & Brown (2001) made similar observations, noting, although teachers tended to ask on average one or two questions every minute, 60% of these related to class management and factual recall with only 20% requiring pupils to think beyond simple recall. Galton, Simon & Croll (1980) likewise reported more than 47% of teacher questions in their study related to routine management. It appears we have not escaped from Flanders' 'rule of two thirds' (Alexander 2000 p.394); that for 2/3 of the duration of most school lessons somebody is talking; 2/3 of this talking is done by the teacher; and 2/3 of the teacher's talk consists of direct instruction in the form of questions, instructions and exposition. If, as the first ORACLE study noted, more higher-order questions were found in whole-class teaching episodes, and the NNS demands more whole-class teaching, an increase in higher-order questioning might be expected. This has not been the case however; Galton et al's (1999) follow-up to the ORACLE project found an increase in whole-class teaching had resulted in teachers devoting even more of their time to telling pupils facts or giving directions. HMI OfSTED (2003) also noted this, their report stressing the need for teachers to make more effective use of questioning to develop pupils' understanding. They claimed in many cases teachers' interpretation and implementation of direct whole-class interactive teaching did not provide sufficiently for open-ended questioning, discussion and collaboration between teacher/pupils and pupil/pupil. More recently Smith et al (2004) reported:

> Far from encouraging and extending pupil contributions to promote higher levels of interaction and cognitive engagement, most of the questions were of a low cognitive level designed to funnel pupils' responses towards a required answer (Smith et al 2004 p.408).

If this remains typical of most classrooms, then students in my study would be unlikely to experience good models of questioning on which to base their own practice. This raises some concern if we heed Alexander's observation, that interaction making high cognitive demands of children is essential for successful teaching. As he notes 'whole class teaching may yield interaction that positively scintillates with cognitive demand, or it may be mind-numbingly pedestrian' (Alexander 2000 p.394).

Discussion and collaborative problem-solving

Alexander's studies (2000) have shown pupils spend a higher proportion of time working when engaged in tasks that involve talking to the class, talking to the teacher, construction, listening or collaboration. Talk, he claims, is essential for both thinking and learning, and is 'arguably the true foundation of learning' (Alexander 2004a p.9), advancing pupils' cognitive and social learning (Dunne & Bennett 1990). Nevertheless, Alexander warns, 'classrooms may be places where teachers rather than children do most of the talking', highlighting 'the seeming paradox of children working everywhere in groups but rarely as groups (and) the rarity of autonomous pupil-led discussion and problem solving' (2004a p.14).

The importance of social interaction in the construction of children's knowledge and understanding was discussed previously *[p.10]* and Vygotsky's view that 'what the child can do in cooperation today he can do alone tomorrow' (1962 p.104), would seem to support a collaborative or cooperative approach to learning. According to Vygotsky, children are capable of performing at higher intellectual levels when asked to work in collaborative situations, than when asked to work alone. He suggests that cognitive conflicts, arising from interactions with more knowledgeable others, induce a process of internalisation and inner speech. Talking together provides a medium for children to become involved in their own learning as they experience this cognitive conflict, begin to accommodate new ideas and understandings, and so actively create meaning for themselves (Mercer & Littleton 2007). Indeed, Peterson (1988) and Simmons (1993) report that pupils discussing mathematics together achieve higher levels than pupils who talk only with the teacher. Berry & Sharp (1999) similarly found collaborative, rather than competitive and individualistic learning experiences, supported and enhanced pupils' learning and promoted higher achievement.

The social learning environment, created through a collaborative learning approach, would seem to provide opportunities for the interaction and scaffolding needed to further children's knowledge and understanding. Mercer (2000) asserts that higher-order thinking and discussion between pupils within a collaborative learning environment enable thoughts and ideas to be developed, refined and explained. If, as Alexander (2004a) notes, this approach is rarely seen in schools, and as Myhill notes 'whole class teaching ... is more concerned with talk for teaching than talk for learning' (2006 p.37), it leaves open to question the models of good practice students would find in partnership schools.

There has been some discussion over the meaning, and therefore use of the terms collaborative and co-operative learning which often appear to be used interchangeably. Gokhale (1995) refers to collaborative learning as 'an instruction method in which students at various performance levels work together in small groups towards a common goal'. (p.1) Co-operative learning, Panitz (1996) explains, has American roots and tends towards a teacher-centred, transmission model of learning whereas collaborative learning has British roots and takes a more learner-centred approach, giving ownership and empowerment to the students through open-ended dynamic tasks. It is this collaborative, problem-solving approach that I see as a feature of effective interactive teaching, rather than the co-operative teacher controlled, closed-problem approach. For the purposes of this study the term collaborative learning will be used and involves pupils or students working together in small groups on a shared activity. This was the approach adopted in the university mathematics sessions, both to enhance students' learning and to provide a model for their own practice. Ideally collaborative learning involves an inquiry-based approach applying key principles of constructivism, with groups investigating significant, real-world problems through good explorative questions of high cognitive demand (Panitz 1996). Collaborative learning also supports and enhances the development of creative thinking and learning. Creative thinking skills underpin the National Curriculum, and should, according to NACCCE (1999) and Fisher et al (2004), be promoted across all subjects. Within mathematics, children need opportunities to generate original ideas, select different pathways, and make decisions, which are addressed effectively through collaborative problem-solving (Fisher 2004). According to Jeffrey et al (2004) and Fisher (2004), children who are encouraged to think creatively are likely to become adaptable, innovative adults, able to solve problems and communicate well with others. These skills are particularly relevant in the current age of technology with change and innovation happening at an unprecedented pace and students were encouraged to develop these skills in university sessions and to incorporate them in their mathematics teaching.

Regardless of the repeated call for the inclusion of problem-solving skills in mathematics teaching, there was a notable absence in the NNS framework of any reference to, open-ended, creative, investigative problem-solving that could support the development of children's mathematical thinking, understanding or application. Yet Cockcroft (1982) had stressed being able to solve problems was the heart of mathematics, and investigation 'fundamental both to the study of mathematics itself and also to an understanding of the ways in which mathematics can be used to extend knowledge and to solve problems in many fields' (para. 250). Fisher (1987) highlights the importance of these problem-solving skills, noting we have survived as humans because we are successful problem-solving animals: 'knowledge is only *of* use if it can *be* used and problem-solving is a process through which we can build on skills and concepts and learn to use knowledge' (Fisher 1987 p.2).

Certainly, for the constructivist, as Cobb et al (1995) point out, substantive mathematical learning is a problem-solving process in itself, suggesting by implication mathematics should be taught through problem-solving. Problem-solving here does not refer to what Orton & Frobisher (1996) describe as closed, 'routine questions arranged in 'exercises', such as are scattered throughout textbooks' (p.19). Rather, as they suggest, 'it refers to the use of novel problems which require children to draw upon previously acquired knowledge and expertise in an intelligent rather than random or routine way' (Orton & Frobisher 1996 p.19/20). Pirie (1987) likens this to exploring an unknown world where the journey (process) is the focus rather than the destination (product). In a constructivist classroom the solving of problems becomes a shared, collaborative activity, presenting an ideal context for pupil/pupil discussion and pupil-initiated questions.

In the next section I address students' learning and development as teachers, considering the physical and social learning contexts, within which their experience of learning to teach takes place.

The Social Context of Students' Learning

From a social constructivist perspective, students are viewed as active participants in their own learning. They interact with each other and their learning environment, bringing prior knowledge, understanding, beliefs and attitudes that will impact upon that learning (Cobb & Bowers 1999). Integral to their development are the physical and social contexts within which this learning takes place. Coming to know how to engage with the culture, discourse and practices of these communities is thus part of their learning (Lave & Wenger1991). As Berliner (2001) suggests, expertise is not simply a characteristic of a person but developed through interaction of the person and the environment in which they find themselves.

As students make the journey from novices, towards becoming expert teachers, Ernest (1989) suggests three elements contribute towards determining the kind of teachers they become: their individual mental schemas, the social context of their learning and their level of reflexivity, as outlined in Chapter One. These three elements cannot be considered in isolation but can be seen to interweave, with students drawing from each as their learning journey progresses. My understanding of this interlinking is illustrated in the diagram below *(Fig.2)* which attempts to show the relationship between the different elements. I have placed the individual, with their preconceived ideas about teaching, their own beliefs and values and their ideals and assumptions, at the centre of two social contexts; the university and the school, represented by the outer ring. These two social contexts are the source of the different ideas, expectations, ethos, culture and values that may challenge or affirm those held by the individual. Through interaction of the individual with these social contexts, students begin to develop their own understanding of what it means to be a learner and a teacher. As Furlong & Maynard explain:

> Development from 'novice' to 'professional educator' is dependent on the interaction between individual students, their teacher education programme, and the school context in which they undertake their practical experience (Furlong & Maynard 1995 p.70).

Novice to Expert: Social Context of Learning

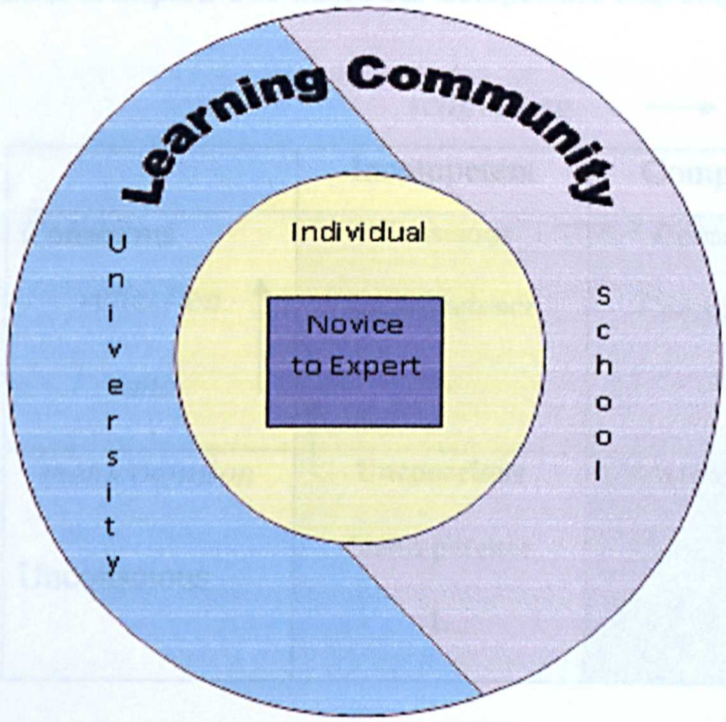


Fig.2

This diagram represents individual learning (novice to expert) set within the social context of the university and partnership schools.

The Conscious Competence Learning Model

The conscious competence learning model (Fig.3), attributed to Gordon in the early 1970s (Howell 1982), presents the learning of new skills, abilities and behaviours as a four stage process from unconscious incompetence to unconscious competence. I have embedded Gordon's model within the 'Individual' element of the Social Context of Learning model above, so illustrating the individual's journey from novice to expert.

Novice to Expert: The Conscious Competence Learning Model

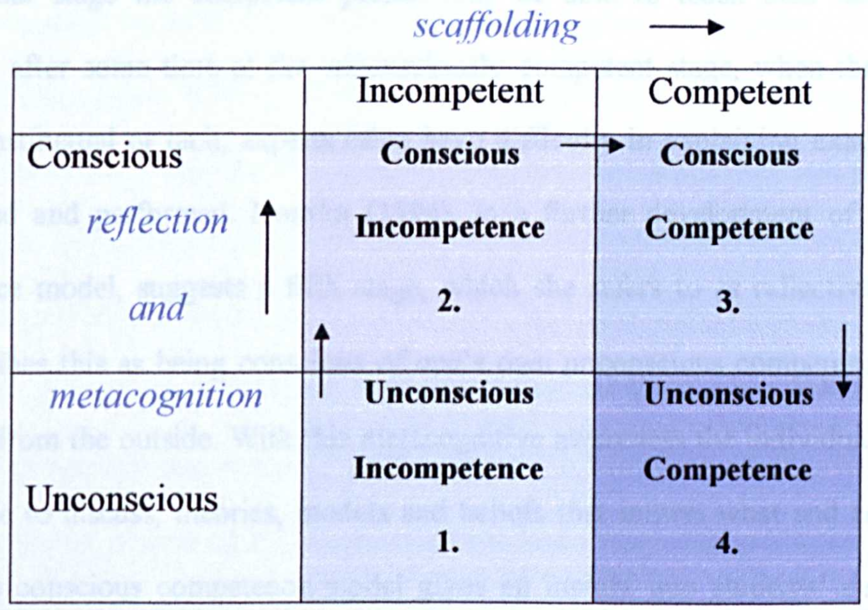


Fig. 3

1. The novice begins in the *unconscious incompetent* stage, unaware of what they do not know or need to know.
2. Through learning experiences they become *conscious* of their *incompetence*, aware of what they do not know and need to learn.

3. Through further successful learning experiences they become *consciously competent;* able to perform the relevant skills reliably but with close concentration and thought.
4. At the final stage they become *unconsciously competent,* where skills are so practised that they enter the unconscious parts of the brain and become second nature.

I have added metacognition, reflexivity and scaffolding to this model (see fig.3) as I believe these facilitate the students' learning journey through the different levels of consciousness and competence.

At the final stage the competent person may be able to teach their skills to others. However, after some time at the unconsciously competent stage, when their skills have become instinctual or tacit, experts often have difficulty in explaining exactly how these are learned and performed. Nonaka (1994), in a further development of the conscious competence model, suggests a fifth stage, which she refers to as reflective competence. She describes this as being conscious of one's own unconscious competence and able to look at it from the outside. With this metacognitive awareness the individual understands, and is able to discuss, theories, models and beliefs that inform what and how things are done. The conscious competence model gives an insight into students' development as teachers. Much of the journey on a one-year PGCE course will be through the unconscious incompetence of the novice, towards conscious competence as a newly-qualified teacher.

As they develop their competence in the practice of teaching, Fuller & Bown (1975) suggest students progress through three stages, each centred on different concerns. These include:

- survival concerns – in this initial stage student teachers focus on getting through the day or, as Feiman-Nemser (1983) describes it, keeping children busy and maintaining order. They try to fit in to the classroom ethos, often emulating the teachers' style (Furlong & Maynard 1995)
- teaching situation concerns – in the early stages of learning to teach the novice teacher tends to adopt an inward-looking or egocentric view, focusing on themselves and aspects of their own planning and delivery
- pupil concerns - as confidence and competence develops, novice teachers are able to focus outside their own performance and begin to recognise and respond to the social and emotional needs of pupils.

Furlong & Maynard (1995) suggest similar stages that incorporate Fuller & Bown's three, but add an initial 'Early Idealism' stage before the 'survival' stage. In this initial stage they describe students as tending to identify with the pupils rather than the teacher, often 'unsympathetic or even hostile to the class teacher' and wanting 'to be seen by pupils as warm, friendly and caring' (Furlong & Maynard 1995 p.73). Furlong & Maynard also add a final 'Moving On' stage when students are challenged to re-evaluate their ideas and beliefs about teaching and so develop 'a more sophisticated understanding of the processes involved in teaching' (Furlong &Maynard 1995 p.95). These stages are not seen as a narrow linear pathway along which students move smoothly, instead 'learning and progress is complex, erratic and in one sense unique to them as an individual' (Furlong & Maynard 1995 p.70).

Fuller & Bown's stages suggest students in my study would be initially concerned with survival and reliant on the model presented by their classteacher. As they progress from this initial stage, becoming conscious of their incompetence, their focus becomes themselves and their delivery of planned material. Towards the end of their final placement, and as qualified teachers, most would be at the consciously competent stage and able to focus on pupils' learning needs. Hence, I set out to explore the extent to which, at these different stages, students would be able to engage pupils in interactive learning that challenges and extends their mathematical thinking.

From a constructivist perspective student teachers' progress can be seen to be supported by the scaffolding of their learning by more knowledgeable others and through their continual reflection on this learning. At the conscious incompetence stage, Atherton (2003) refers to 'Learning as Loss', describing the feeling experienced as individuals relearn or change previously established views and behaviours and find their early idealism challenged. This conflict of old and new ideas and beliefs is essential for learning, creating what Festinger refers to as cognitive dissonance (Atherton 2003). This supports Feiman-Nemser's (2001) belief that initial phases of ITE courses should encourage students to be reflective and question their established views and beliefs (mental schemas) of teaching and learning, set against the new ideas they encounter, so experiencing this dissonance and beginning to identify what is not known and needs to be learnt.

Metacognition; the understanding of one's own thought processes, (Bransford et al 2000), and the ability to monitor one's current level of understanding, is significant. It is only when students become conscious of their strengths and weaknesses and the state of their own knowledge that they can direct their learning to what they do not know. For PGCE students, who may have been confident and successful in previous careers, this can prove to be a deskilling and demotivating experience. Challenging the level of knowledge and experience they once took for granted may create feelings of insecurity and incompetence and engender a crisis of confidence and identity, leaving them perhaps overly reliant on the model presented by classteachers.

The conscious competence model also highlights difficulties students in my study may encounter when attempting to discuss practice with teachers in school. Many experienced teachers will have reached the unconscious competence stage and may be unable to identify and explain the skills and models that, for them, have become tacit. It then becomes difficult for them to scaffold the students' learning effectively through the critically reflective discussion students need to support their development.

Individual mental schemas

Students' established beliefs, values and experiences of mathematics teaching and learning as pupils, are key elements in determining the kind of teacher they will become (Lortie 1975; Ernest 1989; Calderhead & Robson 1991; Pajares 1992; Dunne 1993). Most will join the course having only had direct experience of primary classrooms as learners themselves, within the previous ten years. They tend to rely solely on these limited experiences in their initial reflections on primary teaching (Gates 1994) which, as Borko & Livingstone (1989) point out, is a rather narrow set of experiences on which to base their views and beliefs about teaching and learning mathematics. Lortie (1975) suggests they need opportunities to reflect on and voice these views and beliefs, and explore viable alternatives, if the practice they adopt is to be based on a conscious and informed philosophy.

If students' experiences have led them to see mathematics from an absolutist or formalist view; as certain, exact and made up of skills and fixed methods that one either knows, and can perform correctly - or fails at, then, as Bennett & Carre (1993) note, they are more likely to lack confidence in, dislike or even fear mathematics. Their tendency then is to adopt a didactic, knowledge transmission model of teaching. The alternative relativist perspective sees mathematics as mutable, with a variety of structures, forms and contexts, and tends to promote an open, creative problem-solving approach. Experience of this approach often gives learners greater confidence and liking for mathematics, as 'mathematics is experienced as warm, human, personal .... full of joy, wonder and beauty' (Ernest 1996, p.2). This perspective fosters an interactive, active approach to teaching, where pupils are encouraged to engage actively in their own learning and construct their own knowledge and understanding (Mercer 1995). As Eraut points out:

> teaching strategies of beginning teachers are generally acknowledged to be strongly influenced by their earlier experiences as pupils. People tend to teach, or in a few cases to avoid teaching, in a similar manner to that in which they themselves were taught (Eraut 1994 p.60).

Similarly, Feiman-Nemser (1983), Aitken & Mildon (1992) and Brown et al (1999) found that students tend to revert to models of teaching that resonate with their own experiences as pupils. According to Brown et al (1999 p.310) this is often in spite of a keenness 'to correct the perceived failures of their own teachers'. They suggest, in order to move forward, students will need to discard the affective and subject related 'baggage' they have accrued. It is Brown et al's contention that the failure of teacher education to address this may account for it seemingly having so little impact on students' teaching, and why, as Ball also notes, students 'are most likely to teach math just as they were taught' (Ball 1988 p.40).

My research aimed to explore how students interpreted and implemented what, for many, would be an unfamiliar approach to teaching mathematics. Providing opportunities for them to reflect on and discuss their prior experiences, and explore, challenge and question their pre-conceived ideas, thus became an important aspect of the PGCE mathematics programme. This, I believed, would encourage openness to different views and ideas, which Dewey (1933) suggested was a necessary characteristic of a reflective practitioner, enabling them to explore interactive teaching critically and with more confidence.

The Social Learning Environments

For students, learning took place in two social learning environments or communities; the university setting, and partnership schools. Lave & Wenger (1991) refer to this as situated learning, learning that involves engagement with a particular community of practice, where meaning is not built alone 'but in conjunction with the collected experiences of others' and 'embedded in a culture of learning that is also socially agreed' (Moon 2004 p.10).

In university, through the support of more knowledgeable others, including their peers and tutors, students develop their subject and pedagogic knowledge, becoming familiar with alternative ways of teaching and learning mathematics. Within placement schools they are guided in particular approaches to teaching and managing pupils, observe these being modelled by teachers, and adopt these practices within their own teaching. From these two experiences students begin to construct their own personal knowledge, understanding and identity as novice teachers (Loughran & Russell 1997). Their learning begins in the social arenas or situated learning communities of the university and placement classrooms. What the students see and hear in this social arena is then appropriated, reflected upon and transformed through their personal and individual space, then demonstrated in the social/public space. As Boud et al (1993) explain:

> While learners construct their own experience, they do so in the context of a particular social setting and range of cultural values: learners do not exist independently of their environment (p.13).

Enculturation into communities of practice

In the university setting, students are challenged with new and unfamiliar curricular and pedagogic knowledge and need to balance this learning with experience in schools as novice teachers. Here they are encouraged to assimilate and adapt to the culture and structures of the school community within which they find themselves (Lave & Wenger 1991). With this in mind Korthagen reiterates the importance of students having opportunities to reflect on their prior experience before embarking on practical teaching, so they 'can be armed against socialization into established patterns of school practice' (Korthagen 1988 p.39), which he did not see as always beneficial to their learning.

According to Carter (1990), there is a belief that classroom practice provides the real basis for learning to teach. He suggests students develop their pedagogical skills through reflecting on and refining classroom practice, rather than through typical teacher education courses where, he asserts, they simply learn subject knowledge and procedural rules. Although clearly a vital aspect of student teachers' learning, classroom practice alone may not be a sufficient or positive preparation for teaching. Ernest (1989), Bennett & Carre (1993) and Brown et al (1999) have noted classrooms often constrain students' practice. New ideas for teaching mathematics students developed within ITE courses, they point out, tended to be subsumed by the school's own structural and management concerns, the school's established practice, alongside frequent over-reliance on published materials and commercial schemes of work, providing the model students' were expected to emulate in their own practice. Korthagen (1988) advises students should be armed against such unquestioning compliance.

Students can find it challenging when the models of teaching and learning mathematics, formed from their own experiences, are different from those espoused in the university setting. These may be different again from those practised in placement schools, where interpretation and practice of the NNS model of mathematics teaching have been seen to vary considerably (Moyles et al 2003; Smith et al 2004). This is where the battle between the utilitarian values, often espoused by teachers constrained by government demands, and the perhaps more enlightened views of ITE, and indeed students themselves, become evident. The drive for students to try out new or different ways of teaching, introduced in university sessions, are counterbalanced by diverse constraints, emanating from within themselves (internal) and their school context (external). The practice they adopt depends on the competing strengths of these factors. This struggle can be represented by Lewin's model of **Force Field Analysis** (Schein 1995) *(Fig.4)*. This model provides a framework for looking at the factors, or forces, that influence a situation; those that either drive movement toward a goal (helping forces) or block movement toward a goal (hindering forces), these maintaining a dynamic balance.

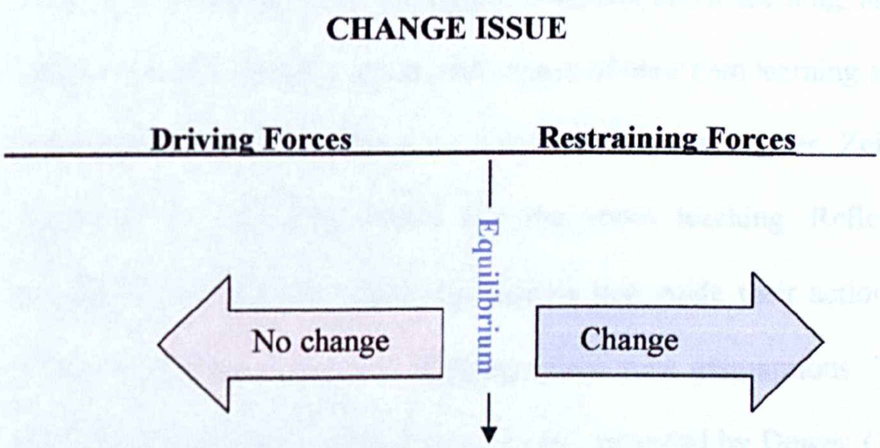


Fig.4

Lewin believed that changes in an individual's beliefs, values, needs, goals, and anxieties, depend upon internalization of external stimuli from the physical and social world, believing this interaction important for development, or indeed, regression. Thus students' development as teachers could be seen as a dynamic battle between their own beliefs, ideals and experiences, and the competing external factors of university and school.

Hence the focus of my study centred around the nature and extent to which these two communities influenced students' interpretation and implementation of interactive teaching.

Developing Reflexivity

The terms reflection and reflective practice have increasingly appeared in descriptions of approaches to teacher education and, as Hatton & Smith (1994 p.2) observe, 'embrace a wide range of concepts and strategies'. Thinking about teaching, and what it means to be a teacher, arguably helps students make sense of their own learning and development. Whilst clear the concept of reflection is central to being a teacher, Zeichner & Liston (1996) caution it is more than merely thinking about teaching. Reflective teaching requires teachers to question the values and beliefs that guide their actions, examine the context within which they work and challenge their own assumptions. This may lead to those feelings of 'perplexity, confusion or doubt', regarded by Dewey (1997 p.12) as the origin of thinking. He reasoned reflection precedes intelligent action and is the act of 'active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends' (Dewey 1933 p.118). Without this questioning approach, and the willingness to seek further facts to corroborate or rescind the suggested belief, teachers often lapse into habitual practice and lose sight of their broader aims and goals in teaching. They come to adopt what Dewey

(1933) refers to as routine or habitual action, 'guided primarily by impulse, tradition and authority' (Zeichner & Liston 1996 p. 9).

It seemed clear, if students were to identify and acknowledge their established views and beliefs, and learn effectively from their experiences within their two learning communities, they would need to become reflective teachers engaged in thinking deeply and critically about their learning and actions in the classroom. As they moved through the stages of learning to teach, university sessions and school experience provided students with opportunities to identify and acknowledge their established views and beliefs, identify what they did not know so needed to learn, and share their experiences. In university mathematics sessions challenging questions were posed, and discussion with peers required students to explain, for example, particular mathematical processes they used and their understanding of these, and consider how they might present these to children. Within school, students were expected to discuss their developing practice with classteachers, mentors and tutors, although the extent to which this involved deeper, critical thinking depended on their individual teachers and tutors. As Zeichner and Liston (1996) point out, schools are complex settings, with their own established and accepted ways of doing things. If this taken-for-granted reality continues without question or challenge then it becomes a barrier to any kind of change or alternative approach. Students, placed within these settings, find themselves quickly absorbed into such routine actions, particularly in the early stages of their development, and are not always encouraged to question and challenge these.

Reflecting on their experiences, and how they are learning, helps students to make sense of these complex professional settings; developing a critical perspective on their practice is an integral part of the interactive process of teaching and learning (Hart 2000; Black 1999). As Brown (1997) explains:

> effective learners operate best when they have insight into their own strengths and weaknesses and access to their own repertoire of strategies for learning (p.411).

For student teachers an important aspect of this metacognition is recognition of the impact the environment has on their learning. Rather than seeing learning to teach as imitating modelled practice, the constructivist views the learner as actively engaged in building knowledge and understanding, through the interplay of new knowledge and experiences with those already held. Through reflection new ideas can be assimilated, creating change in what is already known and understood, a complex process that Piaget (1971) has termed accommodation. Kolb reminds us, 'ideas are not fixed and immutable forms of thought but are formed and reformed through experience' (1984 p.26). In order to move forwards in their learning, students were encouraged to reflect critically on their experiences of mathematics teaching in the two social contexts, considering the prior knowledge that influenced their interpretations and responses to particular events. Understanding their experience and interpretation would be unique to them, and influenced by their own expectations, knowledge, attitudes and emotions, was an important learning step for students. This would enable them to not only reflect on their own learning of mathematics, but that of the pupils they taught, and also arm them against unquestioning compliance (Korthagen 1988).

In my study, the physical and social learning contexts of school and university, the students' own beliefs, values and experiences and the stages of learning to teach through which they passed, were key in exploring students' development as teachers of mathematics. As has been shown in this chapter, the lack of clarity or guidance offered by the NNS appears to have left teachers with little shared understanding of interactive teaching, and little consistency in how they implement this in the classroom. Teachers are constrained by an overly prescriptive strategy driven by the government's focus on a back-to-basics approach, supported by narrowly focused national testing. Studies of teachers' implementation of the national strategies, suggest little has changed in teachers' practice, and utilitarian values remain a driving force. Students, in interpreting and implementing this approach in their practice are likely to be influenced by the diverse and possibly confusing practice they observe and emulate whilst in school and this was the context within which my study took place. Given the time and opportunity to explore interactive teaching in some depth as part of their ITE course, it was hoped student teachers would develop a clearer understanding of interactive teaching and be able to put their ideas into practice in school. Hence key aspects of effective interactive teaching identified within university sessions; pupils' active engagement, questioning, discussion and collaborative problem-solving, became the focus for students' developing knowledge and understanding of teaching and learning in mathematics.

In exploring students' interpretation and implementation of interactive teaching my study addresses a little researched area of student teacher development, responding to concerns that researchers have 'paid too little attention to conducting studies which would support the practice of teaching' (Croll & Hastings 1996 p.3). As such it is hoped the findings will inform ITE and the teaching of mathematics.

3

Research Methods

The research literature and my experience within primary schools and ITE, provide the basis for decisions about the research questions to be addressed, the choice of context, and the methods of data collection and analysis adopted. This chapter comprises three sections, within which I provide a rationale for the epistemological perspective adopted, the methodological approach taken, and the data collection methods I selected. In the first section I consider the purpose and aims of the study and present the research questions to be addressed, followed in section two, by consideration of the epistemological perspective adopted and the research design. In the third section I outline the data collection methods and analysis, justifying the methods employed to address my research questions.

Aims of the study

My research is concerned with the development of students as professionals within a complex mix of the university/school partnership, constraints of government objectives and school cultures. I explore how students come to understand and interpret theory and practice in teaching mathematics within the constraints of the NNS frameworks, with particular reference to direct interactive whole-class teaching (DfEE 1998).

Within this overall aim I consider how students' interpretation and implementation of interactive teaching evolved during their one year training and first year of teaching. In an initial study, which I undertook in September 2004 at the beginning of the PGCE course I gave specific consideration to:

- students' initial experiences, views and beliefs about mathematics
- students' interpretation of the interactive nature of direct interactive whole-class teaching.

The research questions I raised in this initial study were:

1. What are students' views of, and approaches to learning?
2. What was the structure and teaching approach of mathematics lessons students experienced as pupils?
3. What were their attitudes to, and feelings about mathematics at the beginning of their PGCE course?
4. What did students perceive to be the key features of interactive teaching?

This early work was somewhat tentative in nature as I was not altogether clear about the direction my research would take. From this initial study I was able to identify issues that then guided my decisions about how to proceed with the study. The main study, which followed explored:

- students' implementation of key features of interactive teaching
- aspects of the Initial Teacher Education experience which facilitated or inhibited students' implementation of this approach to teaching mathematics.

The specific research questions raised were:

5. Did students include the key features of interactive teaching: active involvement of pupils, the use of questioning and intervention in scaffolding pupils' learning; the use of discussion and collaborative group work and creative problem-solving, in their own teaching in school placements?
6. What were the influences on students' inclusion of these features in their teaching?

The last question was refined during data analysis [see p.84] to become two more explicit questions:

6. How do internal or personal elements influence students' inclusion of key features of interactive teaching?
7. How do external or social context elements influence students' inclusion of key features of interactive teaching?

An interpretivist approach, Nickson (2000) suggests, is 'appropriate to the investigation of the social context of the mathematics classroom, as well as factors such as the values and beliefs that teachers and pupils bring to it' (p.149). This seems appropriate for my study, as I examine students' reflections of their prior experiences, beliefs and values related to mathematics, their interpretation of interactive teaching in mathematics, and their use of this approach in the classroom. Within an interpretivist perspective researchers tend to seek qualitative data and emphasise the importance of developing theory grounded in the context studied.

Ethnographic, interpretive research, which entails detailed scrutiny, tends to produce a large amount of qualitative data, hence a single setting or group, frequently referred to as a case study, often provides the focus (Hammersley 1990). In my study the sample group of twelve students from one PGCE cohort comprises such a group.

Case Studies

A case study is described by Bogdan & Biklen as 'a detailed examination of one setting, or one single subject, one single depository of documents, or one particular event' (1982 p.58), and, according to Walker (1986 p. 189) 'the examination of an instance in action'. Case studies aim to give a portrayal of a specific situation, identifying the particular features of interaction within it through 'real people in real situations' (Cohen et al 2000 p.181) and endeavour to provide 'a rich and vivid description of events' (Hitchcock & Hughes 1989 p.214). Yin (2003) defines a case study as 'an empirical inquiry that, investigates a contemporary phenomenon within its real-life context' (Yin 2003 p.13), Bell similarly suggesting that case studies aim to give 'a portrayal of a specific situation in such a way as to illuminate some more general principle' (Bell et al 1984 p.74). Taking account of these varied definitions, I consider my study a case of interactive teaching in mathematics, as interpreted and implemented by a selected group of PGCE students from one ITE provider. Yin notes that case studies respond to explanatory 'how' and 'why' research questions. My focus on how students' interpretation and implementation of interactive teaching evolves during their one year training and first year of teaching, presents such a question.

Case studies enable learning about a complex event through description and contextual analysis (Corcoran et al 2004), and hence can be seen as illuminative, raising questions about why instances occurred as they did and what might be worth exploring in other similar situations. Case study then is a study of practice, a study of the practitioners involved, and of their actions and the theories they hold about these actions (Corcoran et al 2004). Educational case studies, as Stenhouse (1985) suggests, provide important evidence through which 'comparison and contrast of other cases with one's own' (p.267) can enhance understanding of practice in education.

A case study also enables an open approach to research as, rather than emanating from preconceived ideas or hypotheses, theory develops from an analysis of the data obtained (Glaser & Strauss 1967; Charmaz 2006). Yin contends however that case studies should be used to develop or test existing 'grand theories', rather than generate new theories from data, whereas Glaser & Strauss (1967) claim that there is 'an overemphasis on the verification of theory' (p.1) and consequently less focus on discovering the concepts and hypotheses that are relevant for a particular research area. They note that:

> merely selecting data for a category that has been established by another theory tends to hinder the generation of new categories, because the major

> effort is not generation but data selection. Also emergent categories usually prove to be the most relevant and the best fitted to the data (Glaser & Strauss 1967 p. 37).

I considered it appropriate to approach the study of students' interpretation and implementation of interactive teaching without preconceived notions that might result in selecting specific data, or forcing data already obtained to fit pre-existing categories. This approach can never be regarded as completely open, inevitably there is subjectiveness and selectivity in what one chooses to observe or pay attention to and a belief that what is chosen for study is of importance. Cohen et al (2000) note that this is one identified weakness of case studies, also that they are prone to problems of observer bias, despite attempts made to address reflexivity (Yin 2003). In my study I draw upon students' own interpretations, perceptions and reflections of their practice, using this to corroborate my own observations in an attempt to overcome this claim of observer bias.

A case study approach allows for flexibility and response to specific happenings. As my study focuses on my own setting and involves only twelve participants, this approach enables me to follow up observations and individual responses with further detailed discussions and questioning which, in a large-scale project, would not be possible. Case studies also enable individual voices to be heard, and here the students' own interpretations and perceptions of events, accessed through interviews and discussions, provide valuable data.

Data were gathered via questionnaires, interviews, observations, fieldnotes and student/researcher reflections. The varied and detailed data, and my analysis of these, should be easily accessible by a wide readership. As case studies offer a personal and subjective research approach, the results are not easily generalisable, except in that readers may recognise a case to be similar to others with which they are familiar. Bassey takes the view that:

> an important criterion for judging the merit of a case study is the extent to which the details are sufficient and appropriate for a teacher working in a similar situation to relate his decision making to that described in the case study. The relatability of a case study is more important than its generalisability (Bassey 1981 p.85).

Comparison and contrasting of one case with others may offer new perspectives on practice, generating, what Stenhouse (1982) refers to as a 'consciousness of one's knowingness' (Burgess 1985 p.267). The reporting of individual case studies provides access for interested others, extending their own experiences and enhancing their judgment in a more considered, analytical and reflective way. Bassey notes that if case studies are:

> carried out systematically and critically, if they are aimed at the improvement of education, if they are relatable, and if by publication of the findings they extend the boundaries of existing knowledge, then they are valid forms of educational research (Bassey 1981 p.86).

Thus case studies such as mine have the potential to inform and improve educational practice.

Ethical Consideration

In planning and carrying out this research I was committed to giving due consideration to all aspects of the research process in order that I could 'reach an ethically acceptable position in which *(my)* actions are considered justifiable and sound' (BERA 2004 p.3).

Responsibilities to Sponsors of Research

Permission was obtained from the HEI involved, to carry out the research and the proposed study was approved by the School of Education Ethics Committee in June 2004. Permission was sought, from headteachers and classteachers of the placement schools, to observe and video-record the mathematics lessons *(App.3/4)*. The schools obtained permission from parents and children for video-recording in the classrooms. Schools involved in the observational activities, and the higher education institute within which the course took place, were assured of anonymity and confidentiality, as were the children I observed and video-recorded. As far as possible the video-recording focused on the student and the camera was placed at the back of the classroom to avoid a direct view of individual children. All those involved in the research were assured that video data would be destroyed once the research had been completed.

Responsibilities to Participants

Voluntary informed consent was obtained from all participants prior to the collection and analysis of data. A section on the first questionnaire handed out to all PGCE students commencing the course in September 2004 asked them to indicate whether they were willing for the data to be used for research purposes and their willingness to be involved in further stages of the research *(App.1)*. All 122 students gave a positive response, whilst six declined to take part in further interviews or discussion. The names of these six were removed and a sample selected for further study. Full details of the study, including methods of data collection were outlined for participants with opportunity given for them to ask questions and clarify points. Assurance was given that all data collected would be confidential and pseudonyms used throughout, and if they chose to withdraw from the study all data related to them would be destroyed *(App.2)* (Cohen et al 2000).

My dual role as tutor and researcher involved some tensions, in particular the power and authority dissonance in the tutor/student relationship. As mathematics tutor, my priority and responsibility was developing students' knowledge and understanding of mathematics teaching and learning. I considered it important for participants to know they would not be disadvantaged in any way and feel comfortable and free to express alternative views and ideas. I discussed this concern with them and assured all students in sessions that there was no correct or preferred view of mathematics teaching expected. They were encouraged to be critical, evaluative and to express alternative views to those presented if they chose. A further issue, raised by participants, related to observation and assessment of their teaching in school. I was able to assure them that nothing seen in observations of their practice, or said in interviews or discussions, would contribute to, or be used in any way for assessment purposes. Nevertheless the power and authority dissonance cannot be denied and my dual role as researcher and tutor required a continued awareness and fine balancing of responsibilities. Firstly to the participants and the data provided by them, and secondly to the course demands and expectations, which had to ensure students had every opportunity to meet the required standards to qualify as teachers.

Probing interviews and discussions can sometimes evoke emotional responses or references to personal anxieties or difficulties. Participants were assured that anything they did not wish to be recorded or used as data would be destroyed and that all data would be destroyed after completion of the project. At the end of each interview or discussion the recording, or summary of points made, was shared with participants who could then make changes or ask for comments to be removed if they chose. I considered this an essential part of establishing an atmosphere of trust and students' confidence in being able to speak and act freely.

Selection of Participants

The research reported in this study builds on and is informed by my Initial Study (Sept. 2004), and developed over two years. The Initial Study drew on questionnaires completed by the 122 students who began their PGCE course in September 2004. The questionnaires were completed by students during the first two weeks of the course and explored their initial thoughts and feelings about mathematics and their experiences of mathematics as pupils. All 122 students were willing for their data to be used for research purposes, enabling me to include all data for analysis in the Initial Study.

The initial questionnaire also asked for details of students' age and gender to provide an overview of the cohort *(Fig.5)* and this enabled me to select a mixed sample for later stages of the research.

Age Profile of PGCE Students

	21-30	31-40	41-50	over 50	not declared	Total
Female	73	20	6	1	6	106
Male	8	5	3	0	0	16
Total	81	25	9	1	6	122

Fig.5

Having removed the six completed questionnaires of those unwilling to take further part, the remainder were sorted into age and gender (four age bands and gender for each band). From these four sets, twelve were selected: 6 (2 male and 4 female) from the largest group (21-30 age band); four (2 male and 2 female) from the next largest set (31-40); and 2 (1 male and 1 female) from the smallest set (41-50), so ensuring a range of age and gender from the field (Flick 2006). These twelve were allocated pseudonyms used throughout the study *(Fig.1 p.10)*.

I outlined the proposed research activities to the twelve participants, giving them opportunities to ask questions and confirm their willingness to take part, or to retire from the process. All twelve indicated their willingness to continue.

This was a larger sample than the six I had originally envisaged but I felt it was important to have a significant number willing to stay with the study until the end of their first year of teaching. Beginning with twelve allowed for those who might experience difficulties during school placements and those who might withdraw from the course or the study during the research. It was also possible that, for their first post as teachers, some of the twelve participants would be in an area further away from the university than was practicable to travel for observations. This proved to be a wise decision as some participants were indeed lost from the study. One withdrew from the course at the end of the first term, the remainder completing the one-year course. Once qualified, five were in posts that for a variety of reasons were not suitable for the focus of this study and a further two did not respond to later correspondence. It was only possible therefore to follow four of the twelve through to the beginning of their second year as teachers, which inevitably limits any conclusions that may be drawn from analysis of this final data. This is discussed in the final chapter.

Role of the Researcher

This study involved working within my professional setting, as tutor and researcher. I knew it would be important to establish an open and trusting relationship with the students taking part in the study as we would become closely involved during the research process. I had fully briefed them about the research and obtained their informed consent, and their willingness to take part indicated that a degree of trust and support had already been established. As noted previously, I was aware of the power and authority dissonance that inevitably exists in the tutor/student relationship and knew that this would impact on students' feelings about such trust and support. I held several informal discussions with them to share any concerns about aspects of the research process.

As the researcher, my role varied depending on the setting and I took both a non-participant and participant observer role, depending on the situation. Within the students' school setting my research role was mainly as non-participant observer. I remained at the back of the classroom observing and making notes, or near a group working with a student, trying to remain as unobtrusive as possible. Nevertheless, I was aware that my presence would have some effect on the research setting (Ball 1984). Pupils were aware that I was observing and this may have influenced their responses. The student would also have been aware of my presence and the fact that I was specifically focusing on interactive teaching. This may have made them more nervous or anxious than usual and possibly prompted them to focus more on interactive teaching.

Within university sessions my participation increased as I had a central teaching role in addition to my research commitment. During these sessions my responsibility was to support the students' learning and encourage them to explore the NNS approach. I also circulated, talking to students and responding to their questions. Whilst observing students' activities, listening to their discussions and keeping field notes I was often drawn into conversations with them. I was careful not to impose my views and beliefs, aware of the impact this could have on students' responses to the tasks I set, and on the data I gathered and analysed. This is not wholly avoidable; researcher, tutor and student, all bring their own views and beliefs to the situation. Nevertheless, by being constantly aware of this I was able to question and challenge their beliefs, and remain open to mine being challenged in return. I also became aware that particular reading I suggested students undertake, and my responses to their questions, would undoubtedly influence the direction of their thinking. My early concern was this subjectivity and my inability as participant observer to distance myself sufficiently from what I was observing. As Ball notes, the role of the participant observer is not to stand outside the research but to 'become embedded in the perspectives of those who inhabit the socio-cultural world that is to be described and analysed' (Ball 1984 p.72). In becoming so embedded, as an insider I was more able to access the students' views and beliefs, and their developing mathematical understanding. At a later stage, once removed from the situation, I could take an outsider role and reflect on my observations (Eisenhart 1988).

There is little doubt I had some impact on the discussions and activities in which I engaged with students, and on the data I chose to collect. The aims of my study directed what I chose to observe and attend to, but I was observant of the fact that I might seek out evidence to support my prior assumptions and beliefs. Being open to this possibility to some extent limited its influence, and my reflective journal helped in exploring some of the issues which arose.

From a socio-constructivist perspective I could acknowledge that my own values would inevitably frame and construct what I discovered and moderate and shape what I understood, having implications for me as researcher and the students being observed. I also became aware, prompted by Jaworski's reflections that what I noticed during observations, 'implied some level of significance for me' (Jaworski 1994) p.47) and was only my perception of what happened. I needed to remain aware of my own values, attitudes and prejudices and make these transparent through the research process. Participant validity is one check that can limit potential partiality and ensure shared understanding. I embodied this within the study, through sharing and discussing interview and observation data with the students, checking that my observations and notes agreed with their perceptions of the event. I was then able to use my transcripts, field notes, and video-recordings to support my interpretations.

Data Collection

In planning this study I considered it important that the data collection techniques and methods of analysis employed were driven by the aims of the study rather than vice versa. My research did not begin with a theory or hypothesis to test or prove, rather my early view was that my ideas would develop from the data I collected and theories would gradually emerge from continuous analysis of this data. It is often the case that qualitative researchers follow a somewhat linear journey of data gathering, followed by analysis and subsequent reflection (Charmaz 2006). However a more integrated and circular approach allows development of particular lines of inquiry that arise from initial data, making analysis 'an ongoing, lively enterprise' (Miles & Huberman 1994 p.50). This integrated method of data collection and analysis was the approach I adopted for this study, enabling me to take a flexible response in amending questions, varying ways of recording or adjusting the data to be collected as my ideas became progressively more clearly aligned and focused. Through a process of what Seidel (1998) describes as noticing, collecting and thinking, I aimed to gain insight into, and understanding of, students' engagement with interactive teaching approaches. As Seidel explains, '*noticing* means making observations, writing field notes, tape recording interviews, gathering documents, etc' (p.4). These records are read and things that are noticed are named or coded, then *collected* together and sorted into groups. *Thinking* is the process of examining the data for patterns and relationships within and across the groups created. This was the process I undertook.

An interpretive perspective that focuses on understanding the human experience, requires close, detailed observation and interviews, producing complex data, which may comprise photos, video, audio, field notes and other contextual documents. In an interpretive study the emphasis is on the human being as the primary research tool and the students in my study were to be my primary source of data. My intention was to observe their practice, discuss this with them, reflect on, interpret and seek to understand what I observed (Parlett & Hamilton 1972). My study thus relies on qualitative data, obtained from close observation, participant observation, semi-structured interviews and discussions (Reeves 1996). Nevertheless, that is not to dismiss the place of quantitative data in interpretative, ethnographic studies. Whilst mostly used for testing theory, such data can provide useful information about participants and the area to be explored (Punch 2005). Miles & Huberman argue that:

> both types of data can be productive for descriptive, reconnoitering, exploratory, inductive, opening up purposes. And both can be productive for explanatory, confirmatory, hypothesis-testing purposes (1994, p.42).

For example, in my Initial Study (Sept. 2004), I required information on the initial beliefs and views about mathematics teaching and learning of the cohort of 122 students. I considered quantitative data, gathered via questionnaires, to be most appropriate for this purpose as it enabled me to obtain a large amount of data in a manageable form for later analysis *(App.14)*. Subsequent interviews with a smaller group provided the additional qualitative data I considered important in exploring different perspectives. This combination is characteristic of mixed-method approaches (Burke-Johnson & Onwuegbuzie 2004), increasingly used in studies where quantitative and qualitative data can support and substantiate each other. Such evidence and the way in which it is selected or presented, is open to the researcher's interpretation (Burton et al 2008) and I strived to remain aware of this during the process of selection and analysis throughout the study.

Initial Study

In the Initial Study, students were asked to complete two questionnaires. The first, 'Approaches to Learning' (Berry & Sharp 1999), was a structured questionnaire, focusing on students' approaches to, and views of learning. The second questionnaire focused on students' views and initial feelings about mathematics, and their experiences of mathematics as pupils. These are explained in more detail in appendix 14.

The questionnaires were followed up with individual and group interviews with the sample group of twelve students. As Miles & Huberman (1994) note, a group interview is an appropriate way of exploring questionnaire responses in more depth and I focused in particular on the open question that asked participants for a narrative reflection of their experiences as pupils learning mathematics.

In university sessions I observed students engaged in mathematical tasks and discussions that explored interactive teaching and identified key features of this approach. Here data were obtained from students' written responses to activities *(App.14.4)* and field notes completed after sessions.

Main Study

In the main study I collected data primarily through observation and interviewing. I considered focused observation of students' teaching an appropriate means to provide data on their practice as although it is difficult to carry out unobtrusively, as Morse & Richards (2002) contend, 'observing is the most natural of all ways of making data' (p.96). As Flick (2006) also observes, interviews and narratives merely give an account of practice from the participant's perspective, whereas observation makes the practice itself accessible to the researcher. By both observing students' practice and through subsequent interviews I was able to relate the students' own accounts to my observations.

Observation

In previous research, centred on interactions and communication patterns between teacher/pupils and pupil/pupil, for example the influence of styles of teacher talk on learning (Galton, Simon & Croll 1980), observations have tended to focus upon the verbal interchanges between teachers and pupils. Such observations frequently made use of interaction analysis and systematic observation, such as Flanders' coding scheme; Flanders Interaction Categories (FIAC) (Hitchcock & Hughes 1989). Flanders' overall approach, adopted by Galton et al (1980) was to quantify, in statistical terms, classroom interactions through pre-coded categories using counts or tallies. This approach allows for consideration of a large number of events and enables generalisation from analysis of vast amounts of data. This method of observation, focusing as it does on pre-determined, specific types of behaviour, cannot take into account the nature of the interactions, intentions, or thoughts and views of the teachers, and therefore misses the rich description valued in ethnographic studies.

In my study, as I aimed to explore and seek to understand students' actions, I focused on recording events through field notes and video, rather than adopting quantifiable methods of observation. It is evident that classrooms are complex social environments (Delamont & Hamilton 1984), and as Hitchcock & Hughes (1989) point out, 'the meanings of events which take place within them are not always clearly and automatically self-evident' (p.137). Focused observations of students' use of interactive teaching approaches enabled me to make links between what I observed and what participants recounted.

Interviews

Interviews have been used extensively in educational research as a key technique for data collection (Morse and Richards 2002; Flick 2006)) with considerable diversity in the form these interviews take. The nature of the questions asked, the degree of control over the interview process, the numbers of people involved and the position of the interview in the research design all play their part in determining the kind of data obtained (Gillham 2000). Such interviews can take different forms as Eisenhart (1988) points out, ranging from the highly structured and closely controlled to very informal, conversation type interviews, on a one-to-one basis or with a group of participants.

I chose to adopt a semi-structured approach for all interviews in my study, in order not to overly direct responses. Using few prepared questions enabled me to probe and expand on individual student's views to gain more depth and detail where I felt this was needed (Morse & Richards 2002). It was important in these interviews that students felt at ease and, where possible, a neutral space with easy chairs and refreshments helped to establish this. I commenced all interviews with reassurance that there were no right or wrong responses, and that students' honest views and opinions were important for my research, so they felt able to share their views and opinions without fear of disapproval (Hopkins 1985). Aware of the time involved in lengthy individual interviews, and students' need to fulfill other teaching responsibilities, I tried to keep these discussions to around 20 minutes.

Additionally, being a part-time researcher with a full-time lecturing and student support role, put limitations on my time.

All interviews began with an opening question, for example after the first observed teaching sessions students were asked; 'Tell me about your lesson – in what ways was it interactive do you think?' enabling them to discuss interactive features they had included. I used further prompts to encourage fuller responses where I felt more detail would be helpful and any notes that I made at the time were checked with participants for agreement as to their accuracy. I also recorded the discussions and made these available to participants for corroboration.

Focus Group Discussions

In addition to carrying out individual interviews, I undertook several group discussions with focus groups of six participants. According to Fontana & Frey such groups may 'take many forms depending upon their purpose' (2000 p.651), the term group interview often being used in preference to focus group, as these are frequently interchangeable. Litosseliti's definition of focus groups as 'small structured groups with selected participants, normally led by a moderator' (2003 p.1) aptly describes the groups created in my study, thus I use the term focus groups. Usually such groups are developed to explore specific areas of interest and encourage personal perspectives to be discussed through interaction with group members. Thus peer group discussions enabled me to gain further insights through more probing questions, and allowed the students to discuss their experiences in this relaxed and non-threatening environment. Rather than answer direct questions on a one-to-one basis, students were able to share experiences, interact, and respond to each other in a way that, as Flick (2006) suggests, would further stimulate recall of events, encourage greater honesty and depth, and enable rich data to be obtained (Hitchcock & Hughes 1989). As Flick observes, such group interviews or discussions 'correspond to the way in which opinions are produced, expressed and exchanged in everyday life' (Flick 2006 p.191). In such an environment opinions are offered and may be challenged, changed or supported within the group, through a dynamic process of social negotiation, reflecting the social constructivist perspective of this study. The group interviews were recorded and listened to by students, before being transcribed and analysed.

Video-stimulated recall

Video-recordings of the students' lessons provided the stimulus for students' reflective discussion following observation. As Flick (2006) explains, video-recordings capture more aspects and details than observers can record in field notes, including non-verbal parts of interactions. Additionally, as Pomerantz (2005) explains, in follow-up discussions video-stimulated recall enables researchers to identify subjects of interest and importance to the participants. In my study this was helpful in stimulating students' recall of interactive aspects of their lessons and indicating the particular features focused upon in their descriptions. Thus, video-stimulated accounts were able to 'gain access to the thoughts, feelings, concerns, interpretations, reactions etc.' that were of interest to the students (Pomerantz, 2005 p. 96). The aim of this reflective dialogue was two-fold, firstly, to bring to the fore the students' personal knowledge and professional ideas about interactive teaching and learning in mathematics. Additionally it supported students' development from unconsciously incompetent novices to consciously competent novices by providing them with opportunities to view, discuss and reflect critically on their teaching. Such reflection supports the constructivist view of the learner as actively engaged in building their knowledge and understanding through the interplay of new knowledge and experiences with that already held. Through reflection on their experiences (Kolb 1984) and emerging practice, students had the opportunity to develop and reform their ideas, strategies and ways of teaching mathematics and, through what Piaget (1971) termed accommodation, assimilate and create change in what they already knew and understood.

The use of a video camera in a classroom situation inevitably raises concerns about possible effects on pupils and student teachers that may influence the data collected. Mercer, writing about the use of video in his research, suggests that children are only temporarily and superficially affected by the presence of a camera, noting that, 'early in the initial sessions some children are distracted by the camera, but such signs of interest soon diminish' (Mercer 1995 p.48). The video camera I used was small and unobtrusive and neither pupils nor students appeared distracted by it, both seeming at ease with its presence.

Data Analysis

Most qualitative data analysis involves reading and annotating data and identifying particular aspects of interest. It frequently involves a system of coding and, rather than applying preconceived codes, study of the data provides the relevant codes. Key issues and categories can be derived from the initial data collected, through a process of constant comparison (Glaser & Strauss, 1967). These are then adapted and elaborated as further data are obtained and analysed, thus enabling an explanation of the phenomena to emerge (Cohen et al 2000). I adopted this process in analyzing the data I obtained. My coding categories developed in several stages as early coding labels from the first set of data often proved to be too narrow, too broad or covered more than one attribute of a category.

Initial Study

Qualitative data from the Initial Study questionnaires, which addressed students' experiences of mathematics teaching as pupils, were analysed through line by line coding. Each response was coded, using a variety of coloured highlighter pens, so identifying the different aspects of mathematics lessons reported by students. The highlighted texts were then grouped together by cutting and pasting and overall categories created from this initial coding. Transcripts from follow-up group and individual interviews were coded in a similar way and compared with the first set of coded data. This enabled me to refine the categories and identify overall themes.

Data from activities in mathematics sessions at university provided data on students' developing interpretation of interactive teaching. Concept maps produced by groups of students were coded using various coloured highlighter pens *(App14)* and transferred to separate sheets. From this initial coding various categories emerged and these were presented to the student groups for further refinement. From their discussions four key features of interactive teaching emerged:

- pupils' active involvement,
- questioning,
- discussion
- creative investigative problem solving.

These provided the initial focus for my observations and interviews with students in the main study.

Main Study

Data were obtained from observations of students' teaching and follow-up individual and group interviews. Following each observation and interview, I transcribed the recordings and field notes for analysis. Data from observations were analysed line-by-line using highlighter pens, initially to identify students' inclusion of each of the four features of interactive teaching previously identified. These were transferred to separate sheets enabling each feature to be considered independently, and across all students observed. . I then revisited the data, exploring students' responses to pupils' learning and their non-verbal and affective responses observed during lessons. For example, I had noted when a pupil's misconception or confusion was, or was not addressed and when a student appeared to be uncertain, nervous or lacking in confidence, I coded these and transferred them to separate sheets, compared them across all students observed and noted key categories and themes that seemed to emerge.

Data from follow-up and focus group interviews were coded in a similar way. I again began by coding interactive features, using the four features identified in the Initial Study, then revisited the data, taking a sentence at a time and noting remarks of interest or importance to the student *(App. 7)*. This involved reading carefully and coding comments and responses that seemed to identify students' explicit and implicit concerns, and leads worth pursuing (Charmaz 2006). Based on this initial analysis I planned further interviews following the students' return to university, coding this in a similar process. Further into the data analysis process I made use of the computer software NVivo for the coding process, which made the regrouping or expansion of categories much easier to manage. I collected this coded data together under tentative categories and, through what Seidel (1998 p.4) refers to as a 'thinking process', examined the data for patterns and common threads. My attention was drawn at this stage to aspects students suggested had impacted on their use of interactive teaching and the following aspects emerged as recurring themes; knowledge; fear; role model; teacher guidance and direction; SATs; and time and pace. After further consideration and deliberation, I placed these within two overall categories; internal factors and external factors. At this stage I reconsidered my research questions, in particular question 6: 'What were the influences on students' inclusion of these features in their teaching?'. This I refined and expanded to ask:

6. How do internal or personal elements influence students' inclusion of key features of interactive teaching?
7. How do external or social context elements influence students' inclusion of key features of interactive teaching?

Observations of teaching in students' final practice and new teachers in first posts were supported by vido recordings. These were used to stimulate students' recall and provided support in noting students' inclusion of the four features of interactive teaching. In interviews following the final practice, students' use of questioning was specifically addressed, as it emerged as one feature they had not fully developed in the first school placement. These interviews were recorded and transcribed and a similar process of analysis undertaken. I noted any additional aspects of interest, noticing, in particular, comments students made about constraints on their practice; the theme that had emerged in the first set of interviews. Once these data were coded I returned to my coding from earlier observations and interviews to affirm and refine categories and themes identified. I was then able to consider what data revealed about these students' experiences of learning and teaching mathematics.

Reliability and Validity

Of importance is the extent to which this study could be considered to be reliable and to have validity; whether it can be seen to be dependable and credible. Reliability and validity relate to the quality of data and the appropriateness of methods adopted in carrying out a research project.

In a qualitative study 'authenticity rather than reliability is often the issue', the purpose being to gain an 'authentic understanding of peoples' experiences' (Silverman 1993 p.10).

Silverman suggests this is most likely achieved through use of open-ended questions; the method I adopted in collecting data. In a qualitative study the extent to which the researcher's interpretation of data is a result of conscious, systematic analysis, and is constantly justified, also needs consideration. Silverman further suggests that transcripts of audio-recordings that can be re-visited by the researcher, a method used in my study, offer a highly reliable record.

Hammersley (1990 p.57) describes validity in qualitative research as 'the extent to which an account accurately represents the social phenomena to which it refers'. Triangulation is one method of demonstrating such validity and refers to the use of more than one method of data collection within a single study (Hitchcock & Hughes 1989). As Cohen et al explain, the aim of triangulation is to attempt to 'explain more fully the richness and complexity of human behaviour by studying it from more than one standpoint and making use of both quantitative and qualitative data' (Cohen et al 2000 p.112). Whilst there are advantages to having different sources of data, the use of one data source to validate another is not without its problems as Silverman (1993) notes. If, for example, a documentary source offers a different picture from an observational source, this cannot lead to one being considered more of a 'truth' than the other.

Many qualitative researchers tend to dismiss the assumption, commonly accepted in quantitative research, that there is an external reality against which the truth or falsity of an observation can be set, this being a primary concern of validity (Trochim 2000). This positivist view assumes an external truth that researchers, favouring an interpretivist and constructivist perspective, would dismiss as they consider knowledge and understanding to be socially constructed. Wolcott (1994), for example, prefers to aim for understanding through, what he refers to as 'rigorous subjectivity'. What he claims to seek is, 'something else, a quality that points more to identifying critical elements and wringing plausible interpretations from them, something one can pursue without becoming obsessed with finding the right or ultimate answer, the correct version, the Truth' (Wolcott 1994 p.366). Guba & Lincoln are similarly concerned about the idea of a fixed social reality or truth that remains basically unchanged regardless of one's investigative stance, suggesting that 'triangulation itself carries too positivist an implication, to wit, that there exist unchanging phenomena so that triangulation can logically be a check' (Guba & Lincoln 1989 p.240). The basic question regarding trustworthiness in naturalistic inquiry is: 'How can an inquirer persuade his or her audiences that the findings of an inquiry are worth paying attention to, worth taking account of?' (Lincoln & Guba 1985 p.301). In proposing an alternative to the more traditional quantitatively-oriented criteria as a means to judge the trustworthiness of qualitative research, they propose that the four traditional criteria; internal validity, external validity, reliability and objectivity, be replaced with credibility, transferability, dependability and confirmability. They consider these better reflect the underlying assumptions involved in qualitative research. These criteria had been introduced by Bell (1985) as criteria of rigour in relation to a form of action research she termed 'action inquiry' (p.181). Lincoln & Guba (1985) recommend various strategies for improving the likelihood that findings and interpretations will be credible. One of these strategies is peer member checking, a process whereby participants verify data and their interpretation. Field notes from my observations of students' lessons for example, were compared with the students' own accounts, and their recorded interview responses shared with them, providing member validation (Silverman 1993) and further corroboration of my understanding of their meanings and perspectives. Naturalistic inquiry depends on solid descriptive data, or thick description to improve transferability. Rich description of the experiences and development of the participants is provided, in order to inform those wishing to apply the findings of my study to their own research, Dependability and confirmability were addressed through, my examination and evaluation of the research process and feedback from my research supervisor. Additionally through maintenance of copies of all taped interviews and discussions, notes from observations, interviews and discussions, and hard copies of all transcriptions.

Research Plan

My Initial Study (Sept. 2004) aimed to explore the students' attitudes to, and feelings about mathematics at the start of the PGCE course, their prior experiences of mathematics teaching and learning as pupils themselves, and their developing knowledge and interpretation of interactive whole-class teaching. As Ernest (1989) and Calderhead & Robson (1991) have noted, students' beliefs and prior experiences are strong influences on their own teaching approach and I considered it important to gain some insight into this aspect. In this initial study data were generated from questionnaires, university-based sessions and students' initial observations of mathematics teaching *(App.14)*. The findings are summarised in Chapter Four as they provide the basis for the students' later practice and my observations and discussions in the main study.

Following my initial study, the research developed over a two-year span, with two main periods of data collection. These two periods I related to the conscious competence model, identifying two related themes; 'beginning to know and not know' and 'developing conscious competence'.

Beginning to know and not know (Nov. 2004- July 2005)

This theme related to students' progression from unconscious incompetence to conscious incompetence. Students' developing awareness of the limits of their knowledge about teaching mathematics, and how this influenced their practice, was considered alongside the ways in which students implemented the key features of interactive teaching they had explored in university mathematics sessions.

First school placement

During the students' first six-week school placement in November/December 2004, I observed six of the twelve participants teaching mathematics. These observations usually covered the first ten to twenty minutes of their lesson where they interacted with pupils through explaining, questioning and discussing, before introducing the activities to follow. It was only feasible to observe six of the sample group at this stage as students needed time to settle into their new role and take responsibility for planning and teaching mathematics lessons. This left the final three weeks as the only available time for my observations. I decided that videoing the lessons at this early stage in the students' practice would not be appropriate as it could raise the students' anxiety levels, possibly distorting their behaviour. Instead, I recorded the interactive features; active involvement, questioning, discussion and creative problem-solving observed during the teaching episodes *(App.8)* and kept field notes of students' and pupils' responses and items that struck me as important *(App.12)*.

Follow-up discussions *(App.6.1)*, which I recorded in note form, focused on the lesson I observed, enabling me to access the students' own subjective views (Eisenhart 1988) of the interactive nature of their sessions. These individual interviews encouraged students to explore pertinent aspects of their teaching such as behaviour management and respond to questions that probed specific issues such as their use of open questions. Such in-depth data, I believed could not be obtained by other means.

On the students' return I arranged discussions with two focus groups. This enabled me to explore some issues further and draw upon the experiences of the remainder of the sample group whose teaching I had not been able to observe *(App.10)*.

Final school placement

Between April and June 2005 students undertook a further school placement and I was able to observe ten participants teaching mathematics. Students' inclusion of the four features of interactive teaching, were again the focus of my observations, including any changes in practice from the first school placement. With the agreement of the students, classteachers and schools concerned *(App.4)* I videotaped seven of these lessons and used field notes to record the other three.

At the end of the PGCE course all students in the cohort were asked to reflect on what they considered to have been the greatest influence on their approach to teaching during the course. This provided further data to add to the focus groups views after their first practice. Additionally they were asked, in a short written response, to reflect on their feelings about teaching mathematics. Their responses were coded and themes identified.

Developing conscious competence (November 2006)

This theme related to the students' developing awareness of their knowledge and skills as they began their second year of teaching. At this stage they had become established teachers and had developed their own ways of teaching and managing their classes. With these new teachers I again considered the ways in which they implemented the key features of interactive teaching, explored previously in university sessions.

New Teachers

I observed and/or interviewed four participants at the beginning of their second year of teaching. The data from these provide some insight into students' professional development but this is necessarily limited and I was careful not to draw firm conclusions based on this data. Two lessons were video-recorded, followed by individual interviews. Two further participants were interviewed without lesson observations.

In Chapter Four I summarise findings from my Initial Study as they provide the basis for the students' later practice and my observations and discussions in the main study. I then address the main study, considering participants' implementation of interactive teaching in their own practice.

4

Interpreting and Implementing Interactive Teaching

On the PGCE course the students' learning journey began with university sessions where, through mathematics activities and discussion, their initial views and attitudes to mathematics were explored and they began to develop their understanding of interactive teaching and learning. This part of the research was presented in an Initial Study *(App.14: summary)* and informed the development of my main study. The main study explores students' experiences of implementing interactive teaching in their two school placements and, in the case of four students, also at the beginning of their second year as qualified teachers.

In this chapter I begin by providing a brief summary of findings from the Initial Study. I then consider the first part of the main study; *'Beginning to know and not know'*, addressing students' implementation of interactive teaching in their school placements, and influences on this, drawing on data from my observations, interviews and group discussions. In the final section I consider the second part of the main study; *Developing conscious competence*, examining the practice of four recently qualified participants, through observation and interviews.

Initial Study: Summary of findings

My initial study considered students' beliefs and attitudes towards, and previous experiences of, mathematics. I also explored students' developing knowledge and understanding of interactive teaching in mathematics, based on activities and discussions in university sessions. Data consisted of two questionnaires completed by 122 students, field notes from observations of university sessions and students' completed activities from mathematics sessions.

Students' experiences, beliefs and attitudes

Findings from the questionnaires show that almost all students in this cohort had experienced a transmission-of-knowledge approach to teaching and learning mathematics, described as teacher explanations and examples on the board, followed by the setting of independent work from textbooks. The majority of students expressed strongly negative feelings about mathematics, with over 50% claiming they found mathematics difficult and frustrating *(App.14)*. From responses to these questionnaires, individual profiles were created for the 12 participants, giving an overview of their beliefs and attitudes about mathematics and mathematics teaching *(App.5)*.

The majority of students faced huge challenges if they were to overcome their initial feelings about mathematics and not, as Carre & Ernest (1993) suggest, transmit their apparent fear and dislike of mathematics and lack of confidence to pupils through their own teaching. Ball (1988), Calderhead & Robson (1991) and Pajares (1992) note that students' experiences play a powerful part in determining how they see their role as teachers, this generally reflecting the teaching approach they experienced themselves. The uncertainty and anxiety students had about mathematics, and equally any enjoyment and enthusiasm, was hence likely to be reflected in their teaching.

Understanding interactive teaching

University mathematics sessions aimed to support students in building their knowledge and understanding of interactive teaching and learning in mathematics. Learning was scaffolded through questioning, collaborative group work and discussion, thus providing an alternative experience and modelling the interactive approach I hoped students would adopt. As Richardson (1997 p.35) suggests 'teacher educators must be able to teach in a manner that models the attitudes and behaviours that they would like their preservice teachers to manifest in future classrooms'.

According to Shulman (1986 p.9) to become experts, teachers need to develop competency in three knowledge domains: content knowledge, pedagogical content knowledge and pedagogical knowledge. University sessions addressed these three domains alongside the NNS promotion of interactive whole-class teaching, as weakness in these knowledge areas would likely undermine students' confidence and authority in the classroom.

Features of interactive teaching

The key features of interactive teaching pertinent to this study emerged from activities and discussions with students in university sessions. Moyles et al (2003) found most teachers uncertain about the concept of interactive teaching, evidenced in the varied practice they observed. Hence, they stressed the importance of having a clear underlying rationale and understanding of interactive teaching for teachers to create learning experiences in response to pupils' needs, rather than simply imitate those described in the strategies. The apparent lack of clarity in teachers' understanding and practice led me to ensure students developed their understanding of interactive teaching, before implementing it in the classroom.

As part of their planned university programme, students explored interactive teaching through concept mapping *(App.14)*. These were analysed and common elements across the groups identified. In discussion with students, four overall categories emerged from my provisional coding *(Fig.6)*:

- pupils' active involvement (including practical activities)
- questioning
- discussion
- creative problem solving/investigation

These provided points of departure for my observations of students' teaching and follow-up discussions.

Features of Interactive Teaching

Features	Description
• **Pupils' active involvement (practical activities)**	Use of practical, 'hands-on' activities that actively engage pupils.
• **Questioning**	Use of 'open' and 'closed', 'higher' and 'lower order' questions.
• **Facilitating discussion**	Use of teacher/pupil and pupil/pupil discussion.
• **Creative problem solving/investigation**	Working collaboratively. Use of investigative and creative problem solving activities/ exploring new ideas

Fig.6

This table shows key features of interactive teaching agreed with students. The second column explains these.

Reference to pupils' active involvement in practical tasks as a feature of interactive learning was predominant in most group discussions, students translating the NSS demand for pupils' active engagement as, using practical equipment, doing things themselves, and being actively engaged in answering questions. This, they suggested, reflected the constructivist view of learning, through experience or active engagement with their environment and others. Orton & Frobisher (1996) also note this tendency to relate practical work to a constructivist view of learning:

> although constructivism does not advocate the use of practical work in which children handle and manipulate concrete materials, there is a long history to the commending of the use of 'manipulatives', from the time of Froebel, through Stern, Cuisenaire and Dienes, to today, and there are many who would expect a constructivist classroom to contain a wealth of manipulative materials (p.19).

Group discussions on interaction between pupils and teachers, also produced questioning, discussion and creative problem-solving as further key features of interactive teaching.

Students' observations of teaching

Before their first placement, students spent a short time observing in schools. McIntyre (1988) notes students, not always sure what to look for, or what questions to ask when they observe teachers' practice, tend to focus on surface features; things they can see happening, rather than attempt to seek deeper understanding of these actions,. This may explain the students' tendency to recall children's involvement in practical activities rather than less overt active engagement, such as responding to teacher questions. Freddie, for example, described pupils' active engagement as 'doing things themselves and using practical stuff like the shapes, tape measures, numberlines' (sess. notes 10/04).

From their observations, students reported apparent infrequency in the occurrence of some aspects of interactive teaching. A summary of their observations *(App.14)* indicates a focus on worksheets, drill and practice, and closed questions, with limited use of open questions or creative investigative activities. Students found little obvious change from their own school days, except perhaps increased use of practical activities and manipulatives. Dissonance between ideas espoused in university sessions and practice observed in schools was already becoming evident. As Carre & Ernest (1993) suggest, students were likely to adopt this more familiar, didactic approach if modelled by classteachers. This directed the focus of my main study, which addresses students' implementation of interactive teaching, findings from which are discussed in the next section.

Implementing interactive teaching - knowing and not knowing

Students on the PGCE course develop their pedagogical skills through experience within two social communities; the university, alongside tutors and peers, and their placement schools, alongside experienced teachers, school mentors and peers *[see p.42]*. As they progress through the early university-based phase they become increasingly aware of what they know, and do not know, about teaching and learning mathematics. School placements provide opportunities to develop this knowledge and understanding within a second 'community of practice', where, alongside diverse role models, students put newly-formed ideas into practice. Russell (1988) claims beginning teachers often regard their university-based teaching as irrelevant and unrelated to the reality of teaching, judging classroom-based practice to be a more significant aspect of teacher education courses, and having more influence on their development as teachers (Carter 1990). As classroom practice makes up a large percentage of the PGCE course, this claim is explored in my study.

Students planned and taught mathematics lessons on a regular basis in their two placements, their implementation of interactive teaching in these lessons providing the focus for my observations and post hoc discussions.

First school placement: Nov. 2004

During the final three weeks of their first school placement, I observed six participants teaching all or part of a mathematics lesson, with follow-up discussions immediately after each observation. Initially, students mainly observed classteachers and undertook some group teaching. Gradually whole-class teaching was introduced and, when my observations took place, students were teaching a majority of whole-class teaching for approximately 60% of the timetable. Five observations were of whole-class teaching episodes and one of a smaller group activity. At this stage students' taught sessions were based on their classteachers' weekly plans, these providing the content, resources, organisation and teaching approach they adopted for the remainder of the placement.

Settings

Of the students observed, Harry, Carla and Jared, were with year 4 classes in a junior school whilst Rhea and Saba were with year 2 classes at a primary school, both in Surrey. Freddie was with a mixed year 4/5 class in a south west London primary school. .

Data Collection

The focus of my observations and follow-up discussions was students' use of the four features of interactive teaching identified in university sessions. Field notes were used to record lesson observations, noting activities students included, the questions asked and discussions they initiated with pupils. Notes also included relevant non-verbal and affective behaviours that were part of students' interaction with pupils.

Follow-up interviews centred around three focus questions *(App.6)* addressing;

- interactive aspects of students' sessions
- aspects of interactive teaching they wished to develop
- perceived influences on their teaching approach.

Prompted by notes from my observations, I used additional questions to explore some aspects further, keeping notes of students' responses and corroborating these with them after interview. On their return to university, I interviewed those participants not observed, then met all participants in two groups to explore aspects arising from analysis of individual interviews.

My initial coding of the notes and discussions focused on interactive aspects of lessons, grouped under the four key features identified with students in university sessions. Through further coding I identified other aspects of interest within the data, in particular factors appearing to influence students' practice.

Findings: Inclusion of key features of interactive teaching

This section addresses students' implementation of interactive teaching in their first practice, considering these four features identified in university sessions:

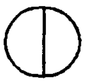
- pupils' active involvement
- questioning
- discussion
- creative, investigative problem solving.

All lessons observed used the NNS three-part structure; a 5-10 minute oral/mental starter, a main teaching part; and a plenary, with students teaching all, or part of, each lesson. The majority of students interviewed regarded the 5-10 minute oral/mental starters as the greatest opportunity for interaction. My findings suggest in this practice students' focused mainly on pupils' engagement in active or practical activities, echoing their focus on this aspect in earlier university sessions.

Pupils' active involvement

In discussing interactive features of their sessions, all began by describing practical aspects they had included; in Carla's words, 'getting them actually doing things and coming up' (FSInt.Carla 11/04). Active involvement of pupils was most evident in the 5-10 minute oral and mental part of mathematics lessons observed. Here students included games and quizzes, often using the interactive whiteboard (IWB), also mini-whiteboards, number cards and counting sticks promoted in NNS training materials. Most students observed involved pupils through use of practical resources and activities, Carla and Jared both used mini-whiteboards, and Harry and Rhea cubes and counters. Harry also included role-play, encouraging six pupils to model an investigative activity (Obs.notes 11/04).

When asked about interactive aspects of their lessons all immediately described practical or hands-on activities, involving manipulative or concrete materials (e.g. Multilink cubes, Dienes materials, clocks and coins), and games, puzzles and quizzes (field notes 11/04). I also noted students' frequent reference to pupils' physical engagement, e.g. coming to the front to show a method on the board, engaging with activities on the IWB, physically representing mathematics problems, or holding number cards. Carla explains; 'I thought if they actually came up and did it themselves then that would ... involve them more' (FSInt.Carla 11/04). Mini-whiteboards in particular proved a popular resource for engaging the whole class at the same time as the NNS recommends. Carla used them in her oral/mental starter for pupils to show answers to addition and subtraction questions (FSObs.Carla 11/04) whilst Jared used them for a bingo game using multiples of 10 (FSObs.Jared 11/04).

Although students explored the idea of active involvement together in university sessions, they had clearly formed their own individual interpretations, these becoming evident once in the classroom. Hiby described it as involving hands-on activities using concrete materials, particularly referring to topics such as measure, that she regarded as more practical (FSInt.Hiby 01/05). Simon similarly described it as, 'having real things like sweets or cars' (FSInt.Simon 14/1/05). Other students seemed to equate the idea of practical or hands-on involvement with visual representations of real-life objects. Saba, introducing her session on fractions, drew a circle on the board to represent a pizza, dividing this into halves with a line down the centre.  She explained she had used the picture on the board, 'so they could actually see me cut up the pizza', adding 'well it was only a circle but they could imagine it – so it was very practical.' (FSObs/Int.Saba 23/11/04). Rhea also used drawn circles, in this instance to represent baskets, drawing eggs in them to make her repeated addition activity, as she said, 'more practical' (FSInt.Rhea 11/04). Saba and Rhea seemed to have taken the word practical to mean the contextual and visual support provided by pictures, rather than practical hands-on experience most students had ascribed to in university sessions. Nell however, described pupils' active involvement in terms of physical engagement:

> where the children actually had to do things … they would have to come out – for example to show numbers on Dienes …and share things out between people … or they'd come up and have to write something up on the board (FSInt.Nell 01/05).

Harry similarly involved six of his pupils in enacting the mathematics investigation 'frogs'; swapping three frogs on lily pads with three frogs on the opposite side, through a series of jumps and slides.

Students' varied interpretation of pupils' active involvement was evident, some seeing this as children being physically active, either out of their seats doing things or using their hands for practical resources, others focusing on the word practical, associating this with a practical or real-life context. This suggests students had not established any shared interpretation of pupils' active involvement, despite discussions in university sessions, hence their practice varied.

Inclusion of questioning

There were few examples of genuine open or probing questions observed in this practice. Students were rarely heard discussing work with pupils in ways that might have provided insight into their knowledge or depth of understanding, or extended their thinking, and pupils rarely initiated talk with the teacher. Rather than scaffold pupils' learning through structured discussion and questioning that built on their current knowledge, or developed their thinking further, my observations showed students tended to give direction, often through the use of closed questions of low cognitive demand, leading pupils to the required conclusion. In this excerpt, the student was working with a group of year 2 pupils on repeated addition, using drawn pictures of three baskets, each containing two eggs.

Rhea: How many lots of 2 are there?

P3: 6?

Rhea: *(Looks doubtful)* Let's look. We've got 1,2,3 baskets with 2 eggs in each so there are how many lots of 2 eggs? *(brief pause)* How many baskets?

P4: 3

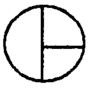
Rhea: Good, there are 3 lots of 2 and 3 lots of 2 is how many?

P3: 6?

Rhea: well done! (FSObsRhea 7/11/04).

Rather than reject or correct the initial incorrect answer of 6, Rhea used this as a starting point. However, she then led the pupil to the answer she wanted through a series of closed questions, in a process referred to by Wood as funnelling (Steinbring *et al* 1998). She failed to explore the initial misunderstanding or respond to it in a way that might have furthered the pupil's thinking. She was also unaware she had changed the direction of her questioning, from 'how many lots of 2?' to '3 lots of 2 is how many?', so adding to the pupil's confusion, possibly due to her own limited knowledge. On her lesson plan, her objectives were clear, and she worked methodically through her planned steps. Her frequent reference to the plan suggests her focus was on delivery of her lesson, rather than the pupils' learning.

On occasion, in their anxiety to ensure planned tasks were successfully completed, students appeared to think for their pupils or answered their own questions. Harry, working with his class on 'frog hopping', took over the thinking for pupils on several occasions, giving directions rather than developing and extending their ideas (FSObs.Harry 12/04). In the interview, he commented on his anxiety that pupils remained engaged and completed the task successfully, and rather than using questions to explore their thinking and reasoning, he took control and directed their next moves. Although most pupils completed the puzzle, under his direction, they learned little in terms of strategies or conceptual understanding that could be applied to similar problems. This was something that may have been achieved with judicious probing questions and more effective scaffolding from Harry.

In sessions I observed, and as Smith et al (2004) and Myhill (2006) similarly noted of teachers, students rarely followed up pupils' responses, or encouraged them to expand on their answers. Generally, pupil responses were simply acknowledged with 'good' or 'well done'; the typical Initiation-Response-Feedback (IRF) sequence described by Sinclair & Coulthard (1975). In one lesson Saba was using a circle drawn on the whiteboard to show two quarters were the same as one half. 

One pupil's response clearly indicated a lack of understanding, which Saba found difficult to address. Having said, 'half is the same as 2/4 isn't it? Does everyone agree with that?' Sam's very doubtful 'No…oo' response (FSObs.Saba 23/11/04) indicated his confusion and uncertainty. Rather than explore this with further questioning, Saba drew another example and relied on a chorus response from the whole class to affirm understanding. She later explained (FSInt.Saba 23/11/04), she had wanted to get through the introduction on her plan and move pupils on to worksheets she had ready. She was certain her repeated example had made it clear and was surprised to find Sam had not completed his worksheet.

Still at the stage of trying to survive each day, as Fuller & Bown (1975) describe, although many students seemed aware of not using effective questioning, their focus was delivering their planned lessons and keeping the whole class working. Carla explains:

> Once they were working I know I didn't use many open questions – I couldn't think what to ask and because I wanted them to be able to finish the work I know I led them to the answers by more or less telling them. … somehow though I think I'm too anxious to get through the lesson and cover what I've planned – I feel I'm under pressure to get it done (FSInt.Carla 11/04).

Carla's comment that she 'couldn't think what to ask' highlights the importance of being confident in, not only knowing the subject, but how to use pupils' responses and explanations to access their understanding, and questions to ask that will extend this further. This required a level of experience and knowledge about mathematics and pedagogy few novice teachers have at this stage. Rhea's comment shows developing awareness of limitations in her mathematics knowledge:

> '… knowing what to ask … knowing enough maths to know what questions to ask that are sort of open – you have to decide at the time and I just couldn't think as well as remember what I had to teach (FSInt.Rhea 01/05).

Several students noted the need to develop their questioning skills, particularly use of open, cognitively challenging questions. It seemed they either lacked the knowledge or confidence in using such questioning or worried about losing control of the lesson direction if they did. Jared recalled, 'this whole idea of higher order and open questions … although I was aware of the fact that we should be using them … because of inexperience it was taking too much time … we just sort of got bogged down in stuff' (FSInt.Jared

01/05). Jared found that pupils' responses to his open questions often diverted him from his planned activities, which were then not completed. Paul was similarly aware of the time issue. 'Questioning skills, I'd probably say I still have quite a bit to learn ... I probably used mostly closed questions I think it's easier to think of these and you can move on quickly to someone else' (FSInt.Paul 18/1/05). Although most students appeared concerned mainly about getting through their planned lesson, a few were beginning to recognize the need to listen and respond to children's ideas. Hiby commented on her lack of confidence in this area, noting, 'I think responding to the children's ideas ... questioning ... it's something I need to work on' (FSInt.Hiby 12/1/05).

The lack of higher-order questioning could also be attributed to factors related to NNS recommendations. Teachers are urged to cover the content of the NNS framework at a lively pace and the time allocated to different aspects of mathematics are presented in the framework on a week-by-week basis. Teachers are aware of demands on them to raise standards in numeracy and SAT results attest to whether this has been achieved, a pressure likely to be passed onto students. Teachers in Moyles et al's study acknowledged these demands, one commenting; 'We've got such a pressure of time that we're just waiting for the right answer because it's much quicker to go on to the next page, and you don't always have time to go through explanations'(2003 p.161). Under this kind of pressure, teachers, and therefore students, are less likely to use cognitively demanding questions that take longer for pupils to answer and often produce unexpected and unplanned responses that divert them from their plans. The drive to maintain pace also lends itself to increased use of quick-fire closed questions. Although increasing the number of interactions with pupils, this is at the expense of more cognitively challenging questions and discussion.

Inclusion of discussion

Little use of specifically planned or directed pupil/pupil discussion was evident in the sessions I observed. Harry was the only student who specifically directed pupils to work together in pairs, using this approach when pupils were solving his frog problem. In High Trees School most teachers encouraged paired work and Harry had been urged by his class teacher to include this in his plans. Nevertheless, although he directed pupils to work together, Harry did not guide this by encouraging pupils to share their ideas, discuss strategies or explain their thinking. Hence in most pairs, the activity tended to be led by the more dominant partner, moves were often made without discussion, or pupils simply worked alone alongside partners. Many pairs struggled to solve the problem posed, thus there was great demand for Harry's attention and an increasing noise level (FSObs.Harry 12/04). Finding whole-class management an issue, Harry seemed unable to develop any meaningful or sustained discussion with pupils that might have helped them to explore, share and evaluate their ideas. As he acknowledged, 'it wasn't easy though – you'd be talking to one or a group and the others would all stop concentrating and start talking or playing around' (FSInt.Harry 12/04). At this stage it seemed most students were more troubled with management issues than with pupils' learning experience. Few students had observed meaningful teacher-pupil or pupil-pupil discussion in mathematics lessons they observed. This, as Rhea said, left her:

> hesitant when attempting to introduce this in my maths lessons. I was worried about losing control of the class as behaviour management was a key aspect of all lessons; I also worried about children losing the focus of the discussion (FSInt.Rhea 01/05).

For Mags, and several other students, encouraging pupils to talk and discuss in mathematics lessons was an unfamiliar and often uncomfortable approach. Mags explains:

> the thing that was the biggest learning curve for me was asking questions and letting the children talk and discuss answers, I found that phenomenally difficult at first ... creating an interactive environment, because again my own experience was someone talking at me and me listening, so I found that very difficult to put into practice (FSInt.Mags 01/05).

Mags' belief that children needed to be 'quietly getting on with their own work' (FSInt.Mags 01/05), was a view she had expressed in university sessions. She also maintained that children sometimes just needed to learn the rules by rote, insisting, 'sometimes you just have to know how and get on with it. That's how it worked for me and I don't think I've lost anything by it' (Fieldnotes sess.1 10/04). Bruner's assertion that 'understanding is fostered through discussion and collaboration' (1996 p.57), although explored in university sessions, seems to have had little impact on her views. Mags' experiences of learning mathematics, although she struggled to learn and found it confusing (Initial Study Q.1), appeared to influence her own teaching approach. Rhea also commented on this impact 'I think sometimes I'm teaching just like I was taught – just because I don't know enough to do it differently' (FSInt.Rhea 01/05). It seems Pajares

(1992) observation that students' own experiences play a powerful part in determining how they see their role as teachers, is evidenced here. His suggestion that students were likely to emulate the teaching approach experienced themselves, appears to be enacted by Mags, and echoed in Rhea's comment.

Inclusion of creative, investigative problem-solving

Only one possible example of creative problem-solving was evident in the first placement. This was Harry's frog problem at High Tree School where, as the school mentor explained, students are urged to include open-ended mathematics activities in their once-a-week class mathematics lesson. Harry began by modelling the investigation using a group of pupils to enact the frog jumps and slides. Notes from my observation suggest he found it difficult to hold the attention of the rest of the class whilst directing this group (FSObs.Harry 8/12/04). This was confirmed when he recalled; 'I found it frustrating getting them to stay quiet and they wouldn't listen, I don't know what else to do' (FSInt.Harry 8/12/04). Moving on to work in pairs, using counters as frogs, many struggled to solve the problem and Harry failed to use questioning to build on their learning or guide them to seek patterns or effective strategies. Instead he used closed, directive questions, enabling pupils to complete the task successfully, but without developing their problem-solving skills and strategies (FSObs.Harry 8/12/04).

My observation notes show Harry found this a challenging session, as he struggled to work with pairs and individuals whilst also keeping the rest of the class focused and engaged (FSObs.Harry 8/12/04). He attempted to make the session lively and interactive but lacked experience in managing the learning and behaviour of a whole class. This became evident as the session progressed, in the increasingly anxious, rather abrupt responses to pupils I observed, and his closed and directive questions.

Summary

My initial analysis of the data had focused on students' incorporation of the four interactive features in their mathematics sessions, as discussed above. It became evident that, at Fuller & Bown's (1975) second stage in their development as teachers, they struggled to cope with interactions that made demands on their mathematics knowledge and experience. With their focus on performance and delivery, they relied on following detailed plans closely, with activities that ensured pupils were busy and under control (Feiman-Nemser 1983). It seemed they were not yet able to focus outside their own performance and so recognise and respond to pupil needs (Fuller & Bown 1975).

Charmaz advises 'the openness of initial coding should spark your thinking and allow new ideas to emerge' (2006 p.48). With this in mind, I returned to data from my observations, discussions and interviews, noticing and coding additional points of interest. This further coding of data *(App.7)* enabled emergence of factors that appeared to influence students' understanding and implementation of interactive teaching and learning. For example, students' levels of confidence in their subject and pedagogic subject knowledge of mathematics, and fear of not being able to maintain control of their class, were two issues mentioned by most students. I grouped and regrouped issues that emerged, eventually establishing two overall categories, which I termed internal and external factors:

- **Internal factors**; pertaining to students' personal learning journey; their knowledge and understanding of mathematics and pedagogy; their confidence, competence and fears
- **External factors** emanating from the school community and culture, and therefore outside students' immediate control; e.g. practice modelled by classteachers, and the need to fit in with school and teacher expectations.

I considered these two categories in relation to the social context of learning model introduced in Chapter Two *[p.43]*. Whilst students may be seen to construct their knowledge and understanding through their personal and individual space (Boud et al 1993), this takes place and is mediated within the wider social context of school and university. The external factors described above emanate from this wider social arena. What students see, hear and experience in the social arena of school is appropriated and transformed, through their personal and individual space, mediated by the internal factors described above. Hence, it was important that both internal (individual) and external (social) factors were considered.

The table below shows these two categories with features emerging from data identified and described within each.

Factors Influencing Students' Implementation of Interactive Teaching

Features	**Description**
Internal Factors	
Knowledge	Students' perceived lack of confidence in their subject or pedagogic knowledge. Students' perceived limits in teaching skills.
Fear	Issues related to management of pupils' behaviour Students' concerns about being assessed
External Factors	
Teacher as role model	Modelled example of effective/ineffective interactive teaching.
Teacher guidance and direction	Students expected to follow teacher's plans, scheme of work or textbooks closely. Teachers' encouragement for students to try new ideas
Time and Pace	Students perceived expectation to complete work or move on as specified in NSS framework
Standard Assessment Tests	Preparation and practice for SATs

Fig. 7

Factors that students' perceived to have influenced their implementation of interactive teaching and learning approaches in the classroom

Internal Factors

Knowledge: coming to know what you know and do not know

In discussions and interviews it became clear that, in having to plan and teach their own lessons, many students had become aware of the limits and insecure nature of their mathematics knowledge. Nell recalls:

> we were doing digital and analogue which I thought I knew 'till I actually had to teach it ... I tried to get them to do things, sometimes it worked, sometimes it didn't because I thought ooh ... it's not as easy as it looks... no really not' (FSInt.Nell 01/05).

Shulman (1986) made the point that weakness in subject knowledge and/or pedagogic content knowledge leaves many teachers lacking the confidence or ability to extend pupils' thinking. This was an evident constraining factor for these students in their early attempts to develop interactive teaching and learning in mathematics. Jared, talking to me before his lesson began, confided he was really worried about teaching mathematics, feeling it was his weakest area. He disliked mathematics at school and still struggled with understanding some of the basic mathematics addressed in university sessions (FSObs.Jared 12/04). If, like Jared, students' own understanding of particular concepts was insecure, then explaining these to children in ways that helped further their mathematical understanding became problematic. Students could give instructions about following a particular process, but could not always break this down, explain it differently, or use appropriate models and representations to help children understand. Often this lack of deeper knowledge was not immediately evident in observations. Harry for example, initially appeared quite confident about his subject knowledge. As his questionnaire in the Initial Study showed, he had found mathematics easy at school, achieving good GCE 'A' level results, and had chosen it as his specialism on the course. Nevertheless, he did not find teaching it as easy as anticipated, as he explains:

> There is so much more to learn than I realised – even in maths which I thought I was quite good at – just explaining things in different ways and often they just don't get it and I can't seem to explain in another way … I can't see what they find difficult. I found maths easy and thought I knew a lot but there's much more to learn when you have to teach it (FSInt.Harry 12/04).

In Harry's case it was not lack of subject knowledge that caused him difficulty, but pedagogic content knowledge, which Ball explains as 'knowledge of what is typically difficult for students, of representations that are most useful for teaching a specific idea or procedure, and of ways to develop a particular idea' (2000 p.245). Rhea similarly acknowledged her limitations in this area, explaining:

> it's knowing the real basics like in place value and fractions – not just being able to do it yourself but I suppose knowing how and why – really understanding so you can explain and so you can help kids when they're stuck' (FSInt.Rhea 01/05).

Teaching unfamiliar procedures, such as chunking for division and the grid method of multiplication, which they first had to learn themselves, proved unsettling for some students, frequently leaving them feeling deskilled and less competent than they first thought. Carla commented, 'I'm worried about teaching maths just because they do things differently now from how I did' (FG2.2Carla 01/05). Freddie, recalling one of his first lessons, similarly noted; 'Ironically the very first thing I taught was partitioning - well I've never done it ... that was quite hard – not knowing myself' (FSInt.Freddie 01/05).

Lacking confidence in their knowledge, these students found it challenging to use a range of questioning, often avoiding asking cognitively demanding questions, or initiating discussions that might expose their lack of knowledge. Jared recalls: 'at the time I wasn't that confident to ask questions – if they went beyond what I knew ... you know I'd panic' (FSInt.Jared 01/05). Concern that pupils might ask questions that went beyond their confidence level prompted several students to keep a tight control on questioning. They seemed to feel more confident using closed questions with a right answer that they knew, worried their knowledge might prove inadequate or they might get caught out and make a mistake.

Fear

In this placement, nervousness and fear were evident in students' teaching in most lesson observations and appeared to be limiting factors in their adoption of interactive teaching. Carla's voice was very shaky as she began her lesson (FSObs.11/04), and she admitted afterwards she had been 'terrified', worried she would not be able to explain clearly and pupils might not listen but would be, 'just talking and playing about' (FSInt.Carla 11/04). Like most students, Carla lacked confidence in her mathematics knowledge and her ability to manage or control the class. Similarly Harry, although beginning his lesson with apparent confidence, gradually lost this as the lesson became more difficult to manage, his nervousness showing in sharp responses to pupils, closed, directive questions and hesitancy in his instructions (FSObs.Harry 12/04).

For most students being observed by their mentor or university tutor was a particular concern, as they feared being judged as failing. Many felt playing safe with straightforward formal approaches was preferable to taking risks and those observing 'watching it all go wrong' (FSIntLise 01/05). Hiby, for example, although keen to develop more discussion with pupils explained, 'I was a bit worried trying it when I was being observed – they're used to children working quietly on their own so trying discussion where they couldn't really explain their ideas or went off the subject made me look as though I couldn't really manage them' (FSInt.Hiby 01/05). Jared echoed this fear: 'well their behaviour, sort of keeping them quiet – that was difficult when they all called out and I thought I can't do this and they don't do it with V.. *(classteacher)* … she must think I'm not much good at this … it's a bit scaring' (FSInt.Jared 01/05).

In this placement, most students cited behaviour management as their main fear. They expressed concerns about losing control of the class and not being able to regain this, or as Hiby and Jared explained, their class getting too noisy, particularly if they encouraged discussion. Students recognised their limited behaviour management skills, and thought activities that encouraged pupils to talk would challenge these. Carla voiced these concerns in one focus group discussion, exclaiming, 'what if they all start talking or aren't listening? I wouldn't know what to do! … if you've got some challenging children in your class it could get a little bit out of control' (FG2:2Carla 01/05). Hence with whole-class teaching, students tended to seek the perceived safety of closed questions to which pupils responded with hands up, thus giving them some sense of being in control.

With their focus on surviving in the classroom (Fuller & Bown 1975), students felt pressure to conform to the perceived good practice of their teachers in terms of control. Denscombe (1984) refers to a hidden pedagogy in schools, which equates success in teaching with good classroom control and it was clear students had become aware of this. Unless specifically encouraged, they appeared reluctant to try different ideas from their classteachers, concerned any resultant loss of control or increased noise levels might bring disapproval and risk of failure as prospective teachers.

External Factors

External or situational factors, emanating from the social arena of individual schools, also strongly influenced students' early attempts at teaching. Over time schools establish a repertoire of ideas, commitments and memories, and develop shared routines, vocabulary and ways of doing and approaching things that reflect the accumulated knowledge of their community (Lave & Wenger 1991). To become part of this community, teachers often need to adapt their personal style to accord with the school's beliefs, ethos and practices. They do not, as Denscombe (1984) notes, 'regard themselves as free agents' (p.134). Leacock (1969) similarly points out:

> Teachers cannot simply interact with the children in their classrooms according to their desires and personal style ... They must adapt their style,

> not only to the children but to the institution, to the principal's requirements, to the other teachers' attitudes, and to the standards according to which they will be evaluated (p.202).

Within these established communities students are merely peripheral participants (Lave & Wenger 1991), hovering around the edges, but expected to adapt to the community's culture and structures. As Schein (1995 p.6) observed students 'can attempt to learn things that will not survive because they do not fit the personality or culture of the learning system', The practice they come to adopt is influenced by a variety of factors within those communities and some of these, emerging from my data, are considered below.

Role Model

In students' placement schools it was classteachers and/or school mentors who embodied the structures and culture, and provided the immediate role models, for students' teaching. As McNamara (1981) points out, 'students, via experience, soak up the unexamined habits of experienced teachers or revert to the methods their own teachers used on them' (p.106). Ball (1988) and Ruthven (1993) similarly note students' observations of experienced and knowledgeable teachers strongly influence their practice. Thus students are most likely to adopt their classteacher's approach, which as Smith et al (2004) assert and students' observations confirmed, has not really changed from traditional patterns of whole-class teaching. If they observed mainly didactic lessons (Muijs & Reynolds 2001) with little meaningful interaction with pupils, as Moyles et al's (2003), Smith et al's (2004) and Burns & Myhill's (2004) studies have suggested, then students were likely to emulate this, particularly if the adoption of a routine, straightforward approach helped to reduce their anxiety.

Data from university sessions in my Initial Study confirmed that the practice of experienced teachers, observed by students, tended to be didactic and teacher controlled. As their experiences as pupils provided a similar model, these were strong restraining forces against students adopting alternative ideas and approaches (Calderhead 1991). Such direct, didactic teaching inevitably had an impact on specific features of interactive teaching students saw modelled. For example, over-reliance on textbooks and worksheets was mentioned by several students. Rosie notes:

> There was a set textbook and every year worked through it... the teacher would explain something for 10 minutes then, right get your books out and ... then for the majority of the lesson they were working independently from a textbook (FG2:1Rosie 01/05).

Several students commented on the similarity of practice they observed to their own experience, reinforcing their view of teaching as transmission of knowledge. Paul notes:

> I didn't see lots of practical kind of things at all it was still... mostly on the blackboard ... most of what I saw was just like I had (FSInt.Paul 01/05).

Nonetheless, where students did have a positive role model, the influence and increase in enthusiasm was evident, as this student's comments suggest:

> A kinaesthetic approach to maths - singing times table songs, dancing the times table dance .... Spending a whole lesson on activities without any written

> work.... what an inspiration – surely the best way of learning maths and becoming confident mathematically (PF8 01/05).

Open, genuine questioning or discussion, particularly between pupils themselves, was not a strong element of teaching observed by students. Where they did comment, the closed or pseudo nature of questions, where teachers seek a predetermined answer, was evident. As Paul recalled: 'you did feel that there was a right answer they had to get ... sometimes they would give answers that could also be right but she was ... well that's ok but that wasn't quite what I was looking for' (FG2:2Paul 01/05).

Although students seemed aware of the differences between open/genuine and closed/pseudo questions, their experience was of teachers' closed questions of low cognitive demand and it was difficult to see how they might gain experience of effective use of genuine, open questions of high cognitive demand. Smith et al, in their study, had noted few opportunities for sustained and extended dialogue by pupils, finding 'teacher questioning only rarely used to assist pupils to articulate more complete or elaborated ideas' (Smith et al 2004 p.409) and Myhill (2006) reported similar findings from her research. Students' observations seem to support these claims, leaving open to question the model of effective interactive teaching they experienced in schools.

Very few students mentioned observing collaborative problem-solving or investigative activities within their schools, adding weight to Aubrey & Dahl's concern that elements stressed in the NNS and SATs, namely mental methods and calculation strategies, 'may overshadow essential mathematical processes such as mathematical investigations and problem solving' (Aubrey & Dahl 2004 p.45). In their study, Moyles et al (2003) found teachers themselves had no clear understanding of interactive teaching and often continued to teach in the way they taught prior to introduction of the NNS. It would seem difficult for students to develop a more interactive approach if this is neither familiar to them, nor supported by the teachers' style or lesson plans they are expected to follow.

Teacher Guidance and Direction

Encouraging students to take risks, try out their own ideas and explore a variety of teaching approaches, is an important aspect of the mentors' role in scaffolding students' learning. Nevertheless, many students felt discouraged from trying approaches at variance with their classteacher's or from being creative in lessons, as they were expected to keep closely to the teacher's plans or school's established scheme and ensure planned work was completed. In university sessions, such plans were introduced as a starting point and students were encouraged to adapt these and include different ideas and ways of teaching. Many, like Simon, found they did not have the freedom to do this: 'my teacher downloads her lesson plans and uses them just as they are – she expects me to use them in the same way and doesn't want me to change them at all' (FSInt.Simon 01/05). Similarly, in discussion (FG2:2 01/05), Hiby remarked she had been told school policy was to use whole class, individual or pair work, but not group work so she wasn't able to use any collaborative group work, making it difficult for her to try out interactive activities discussed in university sessions. Saba also seemed reluctant to try out approaches that were different to her classteacher's. Reflecting on her lesson and the possible use of more questioning and discussion, she explained: 'they always work on their own after the whole class bit – that's how Mrs W. likes it. ... *(she)* is really worried about the SATs this year and is trying to get in lots of practice and make sure she gets through everything. She wants me to follow her plans so that's what I try to do' ((FSInt.Saba 11/04). Saba did not think it a good idea to change her teacher's usual practice as she wanted to fit in and do what she thought was expected of her, fearful of upsetting the children's learning,

Students' desire to become part of their school community, fit in with the culture and expectations and follow the role model provided by teachers, appeared to limit their developing understanding and implementation of interactive approaches to teaching, as McNamara et al (2002) had observed. It was evident the guidance, support and encouragement they received in taking risks and trying approaches that differed from their classteachers' varied a great deal. Often students needed persuasion to move out of their comfort zone and try something different, such as paired or group discussion. They then benefited from knowing the teacher would be ready to give guidance or management support if things began to unravel. Focus group discussions suggest few students had this kind of support, most commenting they just got on and taught, often with the teacher just watching as things fell apart, as Lise had commented in her interview. Thus, students tended to develop coping strategies to manage their anxiety, adopting what they felt were safer, more direct and controlled approaches that followed the class teacher's model. Where teachers and mentors did not offer students guidance and encouragement in taking risks and trying out different ideas, opportunities for them to develop innovative interactive teaching that might challenge and extend pupils' understanding was limited, ensuring they often did not progress beyond didactic rule-based teaching.

Standard Assessment Tests

Even at the beginning of the school year when students' first school placement took place, several found themselves constrained by the focus on SATs as Saba noted *[p.129]*. According to students, requirements for pupils to be adequately prepared to answer test questions proved a factor in the choice of content and teaching approach adopted by classteachers, and these tended to focus on teaching rules and procedures, often through rote learning. Paul and Freddie both commented on their classes doing practice tests and having to focus on the kind of questions pupils needed to be able to answer. As Paul said, he found this focus on SATs restrictive, he would have 'preferred something a bit more practical – a bit more fun' (FSInt.Paul 01/05). As practice tests usually required pupils to work alone in silence, and teaching tended to focus on teaching rules and procedures, these students found limited opportunities to involve pupils in more interactive activities.

Time and Pace

As Moyles et al (2003) and Burns & Myhill (2004) found, the stress put on maintaining 'well-paced lessons' with 'a sense of urgency' (DfEE 1998c p.8) in the literacy and numeracy strategies put undue pressure on teachers. This fast pace in teaching often leaves some pupils struggling to keep up, reflected in the concern of students in my study, whilst needing to cover the planned curriculum in the NNS allocated time presented additional pressure. Carla reported feeling under pressure to get through her lesson and cover what she planned, Other students recognised a fast pace often left pupils confused or lacking in understanding, as Lise explains:

> even if I knew that lots of them didn't really understand, it was, well we have to move on or we won't get through everything,' and so I'd have to leave them confused (FSInt.Lise 01/05).

Nevertheless, as with experienced teachers in Moyles et al's (2003) study, students tended to retreat to, what they saw as the safety of teaching rules and procedures. Although, fast-paced lessons may be helpful in teaching lower-level basic skills, as Muijs & Reynolds (2001) point out, more demanding content requires a much slower pace to allow pupils time to develop understanding. Alexander (2000) warns it is too easy to be seduced by this 'interactive pace' and notes Kyriacou & Goulding's concern that:

> increased use of 'traditional' whole-class teaching with 'pace' is in fact undermining the development of a more reflective and strategic approach to thinking about mathematics, and may be creating problems for lower attaining pupils (Alexander 2004b p.23).

Cognitive demand and pace of learning can be maintained, without succumbing to a mindless pace in delivery, if teachers adopt effective scaffolding to support pupils, ensuring they are cognitively challenged with learning that 'marches ahead of development and leads it' (Vygotsky 1962 p.104). Students would thus have a model of effective teaching on which to base their own practice. If constantly exhorted to maintain a brisk pace in their teaching however, there is little likelihood of more challenging aspects of mathematics being included in their lessons.

Summary: seeking a new identity

Students described being a student teacher, in a new and unfamiliar setting with a different and often confusing role to assimilate, an exciting, but challenging and frightening experience. Having spent 7 weeks in university preparing for this stage in their learning, they were eager to establish their role as teachers and were, as Furlong and Maynard (1995) have observed, full of idealism as they embarked on their first experience of teaching mathematics. For many this experience brought about a realisation that teaching was far more complex and demanding than they had expected, Lise recalling she:

> had all these ideas - but then it ended up all about control, keeping them quiet and on task – not those exciting and fun ideas I had and thought I'd be doing' (FG2.2Lise 01/05).

The school environment was varied and changing and children were individuals with their own needs, abilities and responses. These novice teachers lacked the knowledge and experience to understand or manage all the different aspects the role entailed and, at times, were taken aback by the demands made on their newly acquired, tentative, and often limited, knowledge and skills. This left many feeling deskilled and disempowered and, with anxiety levels rising, they acknowledged it was all a lot harder than they had anticipated. Simon explains:

> I was pretty confident starting out, probably too confident, but reality hit and it was like being that kid in school again I didn't seem to know anything and that's not something I've been used to in work where others would ask me (FSInt.Simon 01/05).

The reality of this transition from student to novice teacher created a degree of dissonance and conflict between the views and beliefs students held about the kind of teacher they wanted to be, and the practice they found themselves adopting. In my Initial Study most students had expressed a desire to make mathematics enjoyable and fun for children with more interaction, group work and fun activities, unlike their own experiences as pupils, sitting listening to teachers and working on their own from textbooks. This was Simon's view, he saw himself using 'lots of interaction' and 'lots more group work and discussion'. However, he described his first teaching attempts as explaining a process to the whole class, using the whiteboard and asking questions to check they understood, then giving out individual worksheets. This, he said:

> was not really the way I thought I'd teach but it's how the classteacher teaches so is what the kids are used to. I don't feel I know enough to change it and I'm worried they'll be all over the place … somehow it feels safer and the teacher likes them working on their own and quiet … it feels like my lessons at school - maybe that's how it's got to be (FSInt.Simon 01/05).

He added that although teaching had 'looked so simple … it proved to be a lot harder' than he had anticipated. Simon, in trying to establish his teacher identity, was clearly struggling to resolve a conflict between his previous view of the kind of teacher he wanted to become and the practice he found himself adopting.

Still at the beginning of a complex learning journey, these students were expected to teach before they really knew how; they were learning by doing, and inevitably were not always successful. Schön has observed:

> the prospective teacher can learn how to teach by encountering the paradox of beginning to teach before they know how, an encounter which assures that the learning process of the beginner will necessarily involve mistakes (1987 p.26).

Hence students relied on support and guidance from more experienced teachers and mentors, as they constructed their own understanding of what it means to be a teacher. Fuller & Bown (1975) and Furlong & Maynard (1995) have both argued that students, anxious about their performance in the complex and challenging world of the classroom, become preoccupied with simply surviving on a day-to-day basis, and, as Feiman-Nemser (1983) notes, focus on keeping pupils occupied with work and maintaining order. Reynolds (1995) made similar observations, noting the focus of students in the early stages of teaching tends to be on their own role in delivering planned material and asking safe questions. Students, he suggests, find it difficult at this stage to take account of the learning and responses of pupils, something they are more able to do as skill and confidence increase.

Data from my study echo these points. Students' initial concerns tended to be centred within themselves; *their* planning, *their* delivery of these plans in lessons, *their* management of resources and *their* control of pupils. Lesson plans students presented at this stage often reflected this egocentrism, with attention focused on what was to be delivered rather than on extending pupils' learning *(App.11)*. Personal or self-centred factors such as confidence, subject and pedagogic knowledge and skills consequently were at the fore and students became increasingly conscious of their level of incompetence, as Gordon's conscious competence model suggests (Howell 1982). Rhea's final interview comment illustrates this well: 'I've just got so much more to learn – I thought I knew quite a lot … now I realise it's nowhere near enough' (FSInt.Rhea 01/05).

There was evidence of students' uncertainty, confusion and insecurity, usually in response to their limited knowledge of the curriculum, teaching activities and school environment. Common to most novice teachers, as Orlich et al (1998) point out, lack of knowledge and experience means students have limited professional insight upon which to base any decisions or choices of action in the classroom, instead they rely on classteachers' guidance. Using teachers' plans, or those from published schemes, and mirroring the teachers' style, or that experienced as pupils, seemed to give students confidence and security, and freed them to focus on performance and delivery, particularly when behaviour management added further challenges.

Frequently, as they became aware of their lack of skills and knowledge, anxiety, fear and loss of confidence superseded students' initial enthusiasm, confidence and excitement. Observations in my study, and similarly noted by Ball (1988) and Brown et al (1999), show students, faced with so much that is new and challenging and liable to raise their anxiety levels, tended to revert to the formal, structured teaching the majority experienced as pupils. This may appear a more straightforward, routine approach to them, thus reducing their anxiety. Feeling teaching is more manageable, they may then show an apparent improvement in their performance and begin to relax a little. They may then reach a static stage where their teaching remains shallow, which Furlong & Maynard (1995) refer to as 'hitting a plateau'; 'having found one way of organizing their teaching that worked for them – they … stick to it' (Furlong & Maynard 1995 p.89). A typical example is Freddie, who said : 'there's a lot to take on that's new and you can't get it all at once ...so you sort of stick with what you know ... what's familiar' (FSInt.Freddie 01/05).

Several students appeared to remain attached to this familiar didactic view of teaching, uncertain about the value of adopting an interactive teaching approach. Carla, Mags and Freddie, continued to believe that direct, didactic teaching might be better and were resistant to letting go of this approach. Mags reiterated points she made in earlier university sessions; that children needed to learn facts, rather than understand or talk about these, claiming, 'I just think there are certain things which I think they just have to know and I think I would still do that ... they've just got to do it - just learn them' (FSInt.Mags 01/05). Freddie, similarly felt more confident with this approach and with tangible, quantifiable evidence of pupils' work:

> it's easier to use those sorts of questions *[closed]*... like with a test ... you can do a test, mark it – Joe Bloggs got 12 out of 20 – you've got a hard and fast record ... to be honest it's what works (FSInt.Freddie 18/1/05).

It would seem that some components of interactive teaching demanded knowledge, skills and experience that, at this early stage of development, these students did not have. Providing practical activities and resources was perhaps most easily ensured, as students could plan and prepare these in advance.

Questioning, as data show, tended to be closed, or funnelled pupils to the required response. Lacking confidence in their subject and pedagogic subject knowledge, students found questions with a correct response easier to manage, particularly as these too could be prepared in advance with answers to hand. Open, more cognitively demanding questions often challenged students' subject knowledge and, as data show, many students lacked the confidence to move away from the security of closed questions. Open questions also require teachers to develop pupils' responses through further questions that challenge and extend their thinking. As we have seen, the focus for students in their first months of learning to teach tends to be themselves and delivery of their planned material. Few appeared to have the confidence, knowledge or skill to listen, respond to and scaffold pupils' learning, or use judicious, responsive and unplanned questioning. Saba did seem to be developing some awareness of this however, as she demonstrates:

> I tried ways to further their understanding … I was working with one of the girls with nets and shapes with the polydron, we'd made this 3D shape and so I thought … to ask her about it and she could explain what she'd done so she'd actually thought about what the lesson was about … … Well after that we were saying well does it? Have a go and try it' (FSInt.Saba 01/05).

Students' use of discussion was similarly limited by their lack of confidence and skill in managing a class of pupils, and lack of encouragement from classteachers. Maintaining control through directed whole-class or independent activities seemed to provide students with a sense of security and success, but rarely enabled them to scaffold or extend pupils' learning. Creative, investigative mathematics again demanded a level of confidence and security in subject knowledge most students did not appear to have developed. Open-ended investigative activities, involving a range of possible strategies, require the open, cognitively challenging questioning students seemed to find difficult. Additionally with pupils following different pathways and needing to engage in discussion with each other and the teacher, class management becomes a challenge. In this first practice, students' reliance on their classteacher as a model for their own practice, and for the content and structure of their lessons, was also a factor. If investigative activities were not part of the teacher's usual mathematics plans, students did not seem to consider including these in their teaching.

These internal and external factors, emerging from the data as influences on students' implementation of interactive teaching and learning, guided the focus of my observations and interviews in students' final placement.

Final school placement April-June 2005

The students' final school experience began in March 2005 with a one-week preparatory period and by week six, they were teaching 80% of the timetable. Ten of the sample group; Freddie, Carla, Hiby, Harry, Lise, Mags, Nell, Rhea, Saba and Simon were observed teaching mathematics in primary schools in southwest London and Surrey.

Data Collection

During this placement I observed ten mathematics lessons; seven were video-recorded, and field notes recorded three. Students' inclusion of pupils' active involvement, questioning, discussion and creative problem solving was again the focus of these observations.

Students watched the replay of video-recorded lessons before follow-up discussions, whilst I shared field notes with the remaining three students before discussions. Semi-structured interviews were used, based on four stimulus questions, which encouraged students to explore interactive aspects of their teaching, aspects they felt needed further development, and how their teaching compared to that experienced as pupils *(App.6.2)*. As many students had struggled with questioning in their first placement, this aspect was explored further in these interviews. Drawing on data analysis from the first placement, students were encouraged to expand on aspects they felt facilitated or constrained their use of interactive teaching, through additional questioning. Interviews were recorded and students listened to, and commented upon these after interview.

On completion of this placement all 121 PGCE students wrote a brief reflection on; their feelings about mathematics; what they now considered important in their teaching of the subject; and what had the strongest influence on their teaching approach. This enabled me to make comparisons with responses in the Initial Study and further data from my observations and interviews.

Findings: Inclusion of key features of interactive teaching

Pupils' active involvement

As in the first school placement, when asked to talk about interactive aspects of their lesson, most students commented on pupils' active involvement. My observations showed that, similar to their first practice, students encouraged pupils to come to the front to place numbers, choose shapes etc. and used the IWB, numberlines and a variety of other manipulatives to further support activities. As in her first practice, Carla stressed the importance of involving pupils in practical tasks, explaining that:

> If they actually came up and did it themselves then that would … involve them more in the session …, I wanted them to do practical activities where they're actually cutting out *(shapes)* or building with them (FPInt.Carla 06/05).

Lise similarly commented on involving pupils; 'I think it was interactive because the children were involved in it and actually doing things', and on developing this aspect further by using the IWB, with pupils 'coming to the front more, maybe to feel the shape in the bag and describing it' (FPInt.Lise 06/05). The IWB was seen by several as a means of increasing interactivity, Simon explaining:

> I can model it on the board, children can come up and they can actually move the ice cream with their fingers and that's through visually seeing the different combinations that they make (FPInt.Simon 06/05).

A more defined understanding of 'active involvement' appeared to have developed since the first placement. Several students commented on giving pupils opportunities to contribute their ideas, as Lise said, 'giving their input' (FPInt.Lise 06/05). Mags similarly believed that asking individual pupils 'to go through some of the key elements of *(a set homework problem)* and offer their solutions, with the rest of the class listening' (FPInt.Mags 06/05), was a way of actively involving her pupils. There was less reference to practical resources except where used to encourage pupils' description and explanation.

There also seemed to be more concern for individual involvement rather than involving as many children as possible through whole-class resources such as number fans and mini whiteboards. It seemed students had become more aware of, and responsive to, individual pupil's learning, moving away from their earlier focus on their delivery and performance.

Inclusion of questioning

In this placement, questioning featured more often in students' observed lessons and post-hoc discussions. Almost all referred to their use of questioning when asked to explain how their sessions had been interactive. Their oral and mental starters included mainly closed questions to rehearse and recall number facts, but in the main part of most sessions it seemed students' increased knowledge and confidence led to greater use of open or pseudo-open questions. These were generally limited however, to asking pupils to describe strategies, explain their thinking or give alternative answers. Most students seemed aware of the importance of cognitively challenging questions and were able to identify and explain when and why they thought they had used these. A few had begun to think of ways to use such questions to scaffold and extend pupils' thinking. Nell explained her aim was to get pupils thinking about the process:

> I tried to ask them questions that were open questions; that were about... what are you thinking? What made you decide to choose this particular area of the grid to solve? I tried to use questions that would get them to think about... how did I do it? ... what informed my decision to make those choices (FPInt.Nell 06/05).

As her confidence in teaching increased so Nell began to focus on pupils' thinking and decisions, suggesting she was moving into Fuller & Bown's stage of 'pupil concerns' (1975 p.37); able to focus beyond herself, and recognise and respond to the needs of pupils.

Lise similarly seemed to have shifted her focus to the mathematical processes pupils worked through, rather than the product of their calculations. Aware that without effective questioning pupils might not fully understand the relevant concepts, she explains:

> I'm trying to get them to think... why is it doing that... why are the units staying the same and the tens changing... and you know what's happening then 'cos they can just say oh it's fifty or it's sixty but not really understand it (FPInt.Lise 06/05).

Both students appeared to have assimilated a key focus addressed in university mathematics sessions; the importance of developing relational understanding with pupils, as well as instrumental understanding; knowing 'why' as well as 'what' (Skemp 1971). As they grew in mathematical knowledge and confidence, they seemed more able to access the levels of pupils' understanding, beginning to recognise the limitations of knowledge without understanding and using this to guide and inform their own teaching.

This shift in focus for students, away from their own performance and towards pupil concerns, became evident in several post-hoc discussions. Both Freddie and Lise mentioned the challenge of trying to include as many children as possible, whilst also addressing individual needs and abilities, so acknowledging the issue of equity in whole-class teaching, raised by Kyriacou & Goulding (2004). Nevertheless, evidence of students further probing pupils' initial responses to questions or extending their learning through use of questions requiring reasons, justifications, implications or inference, remained limited. Although some students attempted to use open, higher-order questioning, most were still struggling to understand and put into practice the full range of questioning skills not yet established within their repertoire. As Saba acknowledged, 'I don't think my questioning skills are developed enough yet, but I think it's getting better everyday' (FPInt.Saba 06/05).

Within a busy and stressful classroom, where students were required to make rapid judgements and decisions, still without the depth of knowledge or experience upon which to draw, it seemed many continued to seek the security of a didactic transmission-of-knowledge approach to teaching. Nevertheless, a few had begun to question and challenge this, and appeared more willing to explore alternative ideas than in the first practice.

Inclusion of discussion

Pupil/pupil discussion was also more evident, and referred to more frequently in this practice, as students developed their confidence in managing the class. Four students observed encouraged pupils to work in pairs to discuss solutions and answers at different points in their lessons, as Lise explains:

> if we're doing paired work and they are giving answers, asking them how did they get to the answer and what did they do to get to that answer … kind of giving them a chance to think about their answers together (FPInt.Lise 06/05).

Her use of some open, probing questions encouraged pupils to think about their learning, how they arrived at their answers, and whether this was the most efficient strategy

(FPObs.Lise 06/05). Rehearsing a process in this way enabled Lise to reinforce pupils' learning, helping them build a repertoire of strategies upon which to draw for similar questions. This was something Nell also acknowledged and several times in her lesson encouraged her pupils to work in pairs, which she felt gave them further confidence and support as she describes:

> I think if you discuss it in pairs if you're not sure it gives you a chance to ask your partner, ... to see how they're thinking, I think it aids their - 'I'm not very confident with this how are you thinking about it?' It also gives them a chance to challenge the other person, 'oh that's not the way I was thinking about it – I thought about it in a different way' (FPInt.Nell 06/05).

Mags too had begun to encourage pupils to work in pairs or groups to discuss their work. Several pupils had struggled with one homework question that required them to find ways of making all amounts from 1p to 10p with only imaginary 7p and 10p coins. Mags encouraged groups to discuss this and share ideas. Later, when asking them to explain what multiples were, she directed them to 'talk about it on your table if you're not sure' (FPObs.Mags 06/05). Her pupil discussions were generally limited to finding the answer to closed questions however, thus her pupils had few opportunities to explore mathematical ideas in depth, evaluate these or scaffold each other's learning. Mags had not fully accepted the value of deeper mathematical discussion and seemed conscious of needing to move rapidly onto the next part of her planned lesson, feeling more at ease with pupils working quietly on their own. As she explained:

> What I find difficult ... is getting them to talk about it ... I'm used to doing the talking and ... well them listening really. I talk, most of the time probably, it's like ... they need to know these things and I need to - well just tell them really. I don't see there's a need for them to be talking (FPInt.Mags 06/05).

For some students managing pupil discussions remained an issue, particularly if the noise level escalated and they felt this suggested loss of control, or it was not consistent with the noise level expected by the classteacher. Rhea found particular difficulties with her class, who were not used to discussing mathematics with each other. She notes:

> they found it difficult to explain their ideas to each other and could get quite silly and noisy. I found that difficult as my teacher liked them to work in silence most of the time and would tell me not to give them a chance to talk, as it was just wasting their time (FPInt.Rhea 06/05).

This lack of encouragement or guidance and apparent assumption that pupils would automatically know how to discuss meant that, rather than help them to develop the skills required, some students, like Carla, would avoid using discussion if it was not initially successful. As she noted, her pupils 'don't really know how to explain their ideas and some don't say anything so there didn't seem any point in getting them to do it' (FPInt.Carla 06/05).

In reflecting on aspects they would like to develop further, Nell, Hiby, Mags and Freddie all mentioned developing discussion in their lessons, using it more often and making it effective by building on the skills pupils needed. However, Freddie and Mags also expressed the view that there were basics children just needed to learn, that sometimes it was quicker and easier to tell them the facts and rules as they learnt more that way and there wasn't time to talk about everything, particularly when driven by the demands of SATs. Mags and Freddie still appeared to be influenced by their own experiences of formal, didactic teaching and their absolutist view of mathematics (Init. Study 09/04). They seemed to be driven by the need to prepare pupils for SAT questions where they felt rules and answers must be *known*. Freddie's views appear not to have changed since the first practice when he commented positively on the value of testing. Nevertheless it did seem that most students, having become more confident in teaching during this final practice, were willing to encourage some dialogue and discussion within lessons and responded more readily to their pupils' responses and learning needs.

Inclusion of creative, investigative problem-solving

Problem-solving featured more frequently in final practice lessons than in the first school placement, appearing in five of the ten lessons observed. Nevertheless, the NC 'Using and Applying' skills explored in university sessions, such as logical and systematic approaches, communicating ideas, developing and explaining different strategies, and recognising and checking patterns, appeared only occasionally in students' planned learning objectives.

It was within activities requiring reasoning and explanation that students' use of open, more cognitively demanding questions, featured most strongly. Hiby, for example, used a function machine program on the IWB to explore possible two-step functions, given a variety of input and output numbers. Pupils were asked to suggest an alternative function, if their first suggestions did not work for further input numbers, then to explain their reasoning. Hiby was confident working with pupils in this way and was able to assess their learning and use questions to challenge and extend their thinking further. Her Initial Study profile *(App.5)* showed that she was at ease with mathematics as a subject and had secure subject knowledge, giving her greater confidence in teaching. She had enjoyed mathematics at school, finding it interesting and satisfying, commenting she had 'patient, kind and cool' teachers who provided her with a good role model for her own teaching (Ques2.Hiby 09/04). Able to draw upon her knowledge and positive experiences when responding to pupils' learning, she was more confident in challenging pupils' thinking and attempting more open and risky activities than most of her peers. Simon, although less confident in his mathematics knowledge, was also keen to provide interesting and challenging investigative activities. In the lesson I observed he worked with his class on finding different combinations of two or three ice cream flavours in a cone, encouraging pupils to use their own methods to explore these, telling them:

> we all have our own ways of working things out which is great – we're going to take it one step further, try if you can to use your plan so far – to help you work out the next answer (FPObs.Simon 06/05).

Simon, when interviewed, said what was important to him in teaching mathematics was to be creative, innovative and 'inspire confidence in the children' (FPInt.Simon 06/05) even though he did not have a great deal of confidence himself.

None of the remaining five sessions observed included creative, investigative or cross-curricular mathematics, where pupils could begin to explore and develop their own ideas and questions. Students reportedly had seen no examples of these in sessions they observed, Nell commenting:

> they haven't really done investigations where they can work together and explore different ways and ideas. They do problems, but it's more the sort of number problems they'll get in the SATs, and they have to work out those on their own (FPInt.Nell 06/05).

With few examples of collaborative investigative activities modelled, or encouraged by classteachers, students were unlikely to recognize their value in extending pupils' mathematics understanding and application, or include them in their own repertoires of interactive teaching.

Problem-solving and inquiry link closely with Myer's view of learning as, 'a 'conversation' in which teachers and students learn together through a process of negotiation with the curriculum to develop a shared view of the world' (1991, p.2). As such, substantial pupil/pupil discussion must inevitably be involved. Hence, with little inclusion of collaborative, investigative problem-solving in mathematics lessons, there are fewer opportunities for pupil/pupil discussion. Abele (in Steinbring et al 1998) has suggested pupil/pupil discussion leads to better understanding of concepts and Bruner similarly commended a 'mutualist and dialectical' pedagogy in which 'understanding is fostered through discussion and collaboration' (1996 p.57). To be able to develop pupils' mathematical understanding through discussion, students need to learn the skills of collaboration and discussion themselves, and although addressed in university sessions, further support and modelling is needed from classteachers in school. Without this, students are unlikely to develop discussion and collaborative learning in the classroom and this became evident later in their practice as qualified teachers.

Factors influencing students' implementation of interactive teaching

Post-hoc interviews with the students, not only addressed their interactive teaching, but also internal and external factors that may have influenced this. Analysis of data from the first practice identified some key factors students felt had facilitated or constrained their use of key features of interactive teaching *(Fig.6 p.98)*, and I drew upon these when analysing interview data from the final practice. The brief reflections completed by all students after the school experience (identified as 04M*n* or F*n* 07/05), contributed further data, adding support to responses from the sample group. In the next section I consider students' perceptions of the impact of these internal and external factors.

Internal Factors

Knowledge

Although their subject knowledge and confidence in mathematics had developed substantially over the course, there were still areas of weakness, particularly in their pedagogic content knowledge. As one student observed, 'teaching it has made me realise that I have significant gaps in my knowledge' (04F33;07/05). As in the first practice, some students, having found mathematics easy as pupils, continued to be surprised at how difficult they found it to teach, and struggled to present concepts in ways children could understand. Several found it frustrating when, as one student commented, 'some children can't get things when it is so obvious to me!' (04F30;07/05). Others, having learnt much of their mathematics in a mechanistic way, found it difficult to explain how and why processes worked, when, as another student explains, 'I don't really understand them myself' (04F2;07/05). Many, having struggled with mathematics themselves and worked hard to further their subject knowledge during the course, felt they could understand the confusion often felt by pupils more easily. They were then able to simplify their explanations and present ideas in ways their pupils could better understand. As Rhea comments, 'I really struggled at school and worried when I couldn't understand and others found it easy so I think I recognise that in some of my pupils and I try to explain it in an easier way' (FPInt.Rhea 06/07).

Unfamiliar methods for calculations, often different from those students learned at school, presented further challenges. This student's reflection was typical of most: 'I find it hard to teach methods that are confusing and different to how I was taught' (04F2;07/05). It seemed that many, conscious of their lack of knowledge and competence, needed to work hard to fill the gaps and extend their own understanding, as this student acknowledges:

> Whilst I understood there was a need to teach it interactively, using children's ideas etc., I now have a broader knowledge and understanding of how to do this ... I certainly have a greater insight into the 'whys' behind maths rather than simply having a bank of methods' (04M2;07/05).

Students' knowledge thus was a key influence on their teaching and their confidence in responding to pupils' confusion and misunderstanding. Becoming aware of what they did not know and could not explain (conscious incompetence), enabled them to seek support in developing their knowledge and understanding and so move towards conscious competence (Howell 1982).

Fear

In this practice there appeared to be less fear of losing control of the class if discussion was encouraged. Nevertheless, it remained an issue for some students, fearing it might cause them to fail their final assessment. Raised levels of classroom noise concerned Rhea, as her classteacher expected the class to work in silence for much of the time and she worried it might seem she could not keep control. Lise expressed similar fears:

> I don't want to make too many changes – you know they might not work and the kids might then be all over the place and then it'll be like I can't manage it … there's the fear that you might fail … (FPInt.Lise 06/05).

This fear of failure arose in several discussions with students and there was a sense that it was better to play safe and follow the classteacher's or year team plans and suggestions. Saba's comment was typical: 'I'm only learning and my classteacher has years of experience … I try and follow her ideas and way of teaching as this obviously works so I suppose I don't really try anything different' (FPInt.Saba 06/05). Many students were aware of their lack of knowledge and experience and this mitigated against trying out ideas different from those established by their classteacher. Instead, they tended to follow these ideas and seemingly successful ways of teaching, without really questioning them.

External Factors

Role Model

As Saba acknowledged above, following their classteacher's approach and ideas often gave students a sense of security in using apparently successful methods. Too often however, the model they were emulating appeared to lack the deeper interactive features that I hoped students would incorporate in their teaching. The majority of observed lessons had a clear NNS lesson structure of an oral/mental starter, usually based on quick-fire closed questions, followed by explanation of the main activity, and pupils' independent work. This appeared to be the model presented by classteachers, but not necessarily one with which students felt happy. As Harry remarked, 'It's not how I see myself teaching but it's how Mrs T. does and I feel I need to follow her lead here, I need to fit in with the school'. He would prefer, he said, 'to do more problem-solving, things they can work on together and use the maths they've been learning' (FPInt.Harry 06/05). Simon expressed a similar need to fit into the school's established approach, explaining:

> It does make it hard as I feel I need to follow her ideas if I'm to fit in with the rest of the year group ... I think I'm right with what I want to do but if it's not what the school does ... I need to sort of fit in, be part of the school – it's difficult to balance – to try my ideas but not do anything too different to what P wants me to do' (FPInt.Simon 06/05).

Students were very aware of this need to fit in and adapt to the practice of their school; to become, as Lave & Wenger (1991) describe, enculturated into that society. Although many struggled, particularly when they felt, as Korthagen (1988) had noted, these practices were not necessarily beneficial to their development or children's learning, as novices they felt unable to challenge the practice they observed, acknowledging their limited knowledge and experience. As Rhea remarked; 'I don't think I can really question the way she works after all she's been teaching a long time and obviously knows more than me' (FPInt.Rhea 06/05).

Teacher guidance and direction

This sense of fitting into the school community and complying with established practice and expectations, also underlined another factor which students' felt influenced their practice; constraints teachers either explicitly or implicitly placed upon them, which students felt often limited their choices. One such constraint, mentioned by many, was the expectation they would follow the already established term's plans. When asked if they could include something more investigative or linked with other curriculum subjects, most students stressed they needed to keep closely to set plans so could not be more creative. Several students experienced this limited freedom to create their own lesson content, as Saba, talking about trying to balance her ideas with her classteacher's, commented:

> The plans are already done and we go over them at the weekly meeting – I did try suggesting doing something slightly different one week – just an idea from one of the uni sessions but they said they'd done the lesson before and it worked so … not to change it (FPInt.Saba 06/05).

Without the opportunity to create their own plans, students were less likely to have the confidence needed to do this as teachers and more likely to become reliant on published schemes and worksheets that are not respondent to pupils' needs.

Teachers not only expected students' compliance to curriculum plans, but in two cases students reported the expectation that every pupil would produce written work in their books each lesson, as evidence of their learning. Paul recalled a lesson he taught where pupils worked in pairs on a series of place value activities not requiring any recording. His classteacher's lesson feedback included the comment, 'you have to make sure they all show some work in their books so there is evidence of the maths they've done' (FPInt.Paul 06/05). Paul felt this would have detracted from the children's enthusiasm and their learning, but felt he had to comply, becoming reliant on the teacher's prepared worksheets and written exercises.

Standard Assessment Tests

The pressure of SATs appeared to be an influential factor in this final practice, several students finding their mathematics lessons geared towards SAT revision exercises. Needing to get through the work pupils had to cover, and expectations they would teach pupils rules and procedures required for answering SAT questions, inevitably became important driving forces for many students. This, seemingly more so than the desire for pupils to understand concepts and apply their knowledge, through protracted open-ended collaborative activities. Paul's comment supports this concern; 'my teacher is obsessed with the SATs coming up, every lesson has been a revision but it's just going through the rules ... if you see this it means you've got to do such and such, no understanding just follow the rules' (FPInt.Paul 06/05). This experience added little to Paul's understanding of effective teaching of mathematics, or of interactive teaching and learning. Mags, however, seemed to feel at ease with this more didactic approach that resonated with her own experience of learning mathematics, which she said was, 'quite direct ... more disciplined ... which I found quite pleasant actually because I instinctively liked the idea of control' (FSInt.Mags 01/05).

It seems Thompson's (2001) concern that 'testing' had become a more important focus for schools than the learning the tests supposedly represent, was supported by these students' experiences. Additionally, teachers' concerns that pupils were being taught 'to jump through hoops' voiced in the OISE/UT study, (2001 p.72) also seemed to be borne out and pupils were not developing deeper levels of understanding and application necessary for creative problem-solving.

Time and Pace

Time continued to be an issue for several students, one reflection noting, 'time restrictions to get through the curriculum often doesn't allow for much time to consolidate or readdress problems/shortfall in understanding' (04F8;07/05). Most students reported being told to 'up the pace' (FPInt.Hiby 06/05) to make sure they moved onto the next mathematics topic planned. Hiby recalled being told 'you need to make sure they've finished that section as they have to move onto fractions on Monday' and, having raised concern about some who were still struggling to understand the current topic, was told 'they'll have to catch up next year, we can't wait for them now' (FPInt.Hiby 06/05).

The need to complete planned work and move on quickly did not encourage students' inclusion of creative or investigative activities, likely to take longer than, for example, sets of practice exercises, and this tended to encourage reliance on worksheets and textbook exercises. Freddie's comment that, 'It's a bit of a rush so you keep the pace up and they've just got to keep up – they've got to just know that 2 and 2 is 4, just know not talk about it' (FPInt.Freddie 06/05), shows how this stress on pace can lead to mechanistic learning, rather than understanding and application.

Summary

In this final school practice there was evidence that many students were moving into Fuller & Bown's (1975 p.37) third stage of novice development, where their focus moved towards 'pupil concerns' rather than their own performance and delivery. Many traits of novices, identified by Orlich et al (1998 p.14) remained evident, notably their still limited knowledge of the teaching environment and teaching activities, their feelings of uncertainty, confusion and insecurity, and reluctance to try new teaching methods. Nevertheless, it was noticeable that many students were beginning to move away from these, evidenced in their increasing knowledge and confidence, albeit hampered at times by the constraints of school culture and teacher expectations.

The first practice had shown inclusion of practical activities a key focus, students seeing this as a tangible representation of children's engagement with their learning, and something they seemed to find easier to address. In the final practice there appeared to be a shift of focus for students, away from themselves, the practical resources they used in lessons and strict adherence to their plans, and more towards the pupils and their contribution to the learning process. Lise, explains 'I questioned them about their ideas … and also about what I'm going to do next as well – what I need to do to move them on'

(FPInt.Lise 06/05). The practical activities had become a support, rather than the focus of their teaching, with more time given to interacting with pupils through questioning.

Although students' subject knowledge had developed during the course, many continued to struggle to transform this 'into forms that are pedagogically powerful' (Shulman (1987 p.15), such as analogies, illustrations, examples and explanations that help pupils to understand mathematical ideas. Nevertheless it was evident the increased knowledge and confidence of many students led to greater use of open and cognitively demanding questioning that explored pupil's ideas and strategies. Closed questions continued to dominate however, and scaffolding pupils' learning, by extending and challenging their thinking, remained an under-developed area. Notable in this practice was increased use of discussion, as students' developing skill in managing whole classes appeared to give them more confidence in encouraging pupils to talk about mathematics.

Students' inclusion of creative, investigative problem-solving also increased in this practice although many continued to lack the confidence, or encouragement from their classteachers, to explore this approach further, as Nell's comments above [p.150] suggest. The talking and discussion involved in open investigative tasks meant students felt less in control of the outcomes, and it was easy to see why they, and indeed practising teachers, may have been reluctant to use such approaches. It is apposite to recall Alexander's (2000) contention, that the most potent activities for generating pupils' learning are those involving structured talk and pupil/pupil collaboration rather than reading or writing activities. The learning resulting from such activities however, is often not as tangible as that perceived from sets of written and marked exercises, and few students, or teachers it seemed, had the confidence to include such activities in their lessons, the pressure of time, targets and SATs seemingly mitigating against this.

Still at the stage of consciously incompetent novices, there remained a tendency for students to rely on the safety of the teaching model experienced as pupils, much more controlled than an interactive approach encourages. This seemed to direct many away from collaborative, creative, investigative activities that required them to relinquish control to pupils, encouraging them to raise their own questions, and explore and investigate these. Students were aware they still had much to learn to become teachers, but discussions with them indicated they were reflecting thoughtfully on their practice and furthering their knowledge and understanding through this. As Saba explained:

> I need to keep learning and keep creating... I want to make maths accessible to everyone even if it's not a strong subject for them ... by learning from others, using other people's ideas and adapting them (FP2Obs.Saba 06/05).

Common with most students, she recognised the benefits of working collaboratively and learning from others.

Students' final reflections

The idea that practitioners can improve their own practice through reflection has long been recognised (Schön 1987). By looking back thoughtfully on their experiences, students are able to move forward in their development. At the end of the PGCE course all students in the cohort were asked to provide a written reflection on what they considered to have most influenced their approach to teaching during the course and also their feelings about teaching mathematics, so adding to focus groups' views obtained after the first practice. Responses were received from 104 students; 90 female and 14 male, these were coded and emerging patterns and themes identified.

Taking a constructivist perspective, my aim in university mathematics sessions was to model an interactive approach, actively engaging students in constructing their knowledge through collaborative discussion. The students' positive view of these sessions was evident in their responses and reflection on what most influenced their approaches to teaching mathematics. Jared and Harry's comments, typical of many, illustrate this:

> I think from the course really … I didn't know anything about teaching maths … perhaps if I hadn't been on this course I would have just walked into a school and taught maths like I was taught (FSInt.Jared 18/1/05).

> What we've been taught here in lectures, the way everything has been put showed me that there were other ways to learn maths not just the way I was taught (FSInt.Harry 11/1/05).

Of the final reflection responses, 87% claimed university sessions were the strongest influence on their teaching, challenging their views and introducing different ideas and approaches. One student commented, 'the course has made me believe in interactive maths work, pair discussions, giving thinking time before answering and pupils being the lead role in a group… It is much more exciting than I predicted!' (PF27;07/05). Reducing students' fear and increasing their confidence had been one aim of the mathematics team and, in this respect, the approach adopted seems to have been successful. This student's reflection was typical of many: 'I was really worried about maths at the start of the course but the maths sessions were fun and I felt I could get things wrong and could ask if I wasn't sure. This gave me much more confidence' (PF15;07/05).

13% of respondents also appreciated seeing experienced teachers put into practice ideas introduced in university sessions. Nevertheless, as noted previously, observing experienced teachers was not necessarily positive for students, as the majority observed a didactic approach with extensive use of textbooks and worksheets. Although students overwhelmingly felt university sessions had influenced their ideas and practice, it was clear from my observations and interviews that their classteachers' practice and expectations were the stronger influence on what and how they taught.

At the beginning of the course, many students had been very anxious about the prospect of learning and teaching mathematics, certainly not anticipating ever enjoying it. By the end of the course the majority of reflections showed feelings about teaching mathematics had changed significantly; almost 50% of respondents said their confidence had increased and over 50% commented, often with surprise, how much they enjoyed teaching mathematics, represented by this student's reflection:

> My attitude towards teaching maths has completely changed since the beginning of the course. I now feel very confident in most areas and have enjoyed teaching it. (F14;07/05).

Nevertheless, it is interesting to note students' responses were not demonstrated in the practice I observed. Whereas many expressed positive views about interactive approaches, where mathematics was lively, interesting, engaging and involved much talk and discussion, few students had confidently introduced these aspects in their lessons. This suggests the driving forces for this approach, from the university-based course and from students' research, and increasing skills and understanding, were not strong enough to resist the restraining internal and external factors of self and schools.

Developing Conscious Competence: The New Teacher

Students began their first posts as newly-qualified teachers in September 2005 and data were collected at the beginning of their second year of teaching, in November 2006. This gave newly-qualified practitioners a year to establish themselves as teachers and develop their own ideas and approaches to teaching mathematics. I was able to observe and interview only two of the sample group; Mags and Saba, and interviewed a further two; Harry and Freddie, thus any conclusions must remain tentative.

Data Collection

Data were collected from observations and video-recordings of two mathematics lessons, and interviews with four new teachers, which focused on their inclusion of interactive features. The video-recordings were watched by teachers, followed by semi-structured interviews, using six key stimulus questions *(App.6.3)* exploring their understanding and use of interactive teaching. Teachers were encouraged, through additional questioning, to expand on aspects they felt facilitated or constrained their use of interactive teaching. Interviews were recorded, and teachers listened to, and commented upon these before transcription and analysis.

New Teachers' Inclusion of key features of interactive teaching

Pupils' active involvement

Although as students they had tended to focus on practical activities during school placements, this was neither evident in the two observed lessons, nor referred to by Harry and Freddie when interviewed. No practical resources were used in the sessions observed, their absence commented on without prompting, by both teachers in post-hoc discussions. Pressure of time proved an issue for Saba, who felt she was now less creative and inventive than during her school placements, having less time now with so much planning and teaching. The school context clearly had an impact on Saba's practice, evidenced in her concern about lack of resources available to support children's learning. She explains:

> resources and things are a bit tight ... you don't have as much as you want to be able to do things I've seen in other schools (NTInt.Saba 11/06).

Mags made no reference to use of practical materials, until asked if she remembered anything in particular from the university mathematics course. She then recalled the practical aspect, admitting she didn't use practical materials much herself:

> the thing that struck me, ...was where you used ... such tangible things to demonstrate and I'm not very good at that ... I've got lots of shapes down there – quadrilaterals and I never got them out and we've done 3 days on quadrilaterals, because somehow or other I don't think about it ... I do it all with paper or on the board (NTInt.Mags 11/06).

Mags appeared to have adopted a traditional didactic teaching approach, relying on direct instruction and boardwork, clearly reverting to the familiar style of her schooldays, which she found more comfortable, readily admitting:

> Well you see I have reverted to type, I'm sorry to say ... because if you remember way back when I said well I'm used to very structured and very disciplined and ... not a lot of noise ... because that's how I was taught - and I have reverted to that type'(NTInt.Mags 11/06).

Asked why she thought she had reverted to this approach Mags was clear it felt right: 'Because I think it's a natural... it's a comfort zone to be quite honest'. Ball's (1988) assertion that teachers tend to teach how they were taught themselves, seems to be supported by Mags' example. As a mature student her beliefs and ideas were firmly established, and seemingly not changed significantly by the challenges of the PGCE course.

My observations show all four used games and quizzes, usually in the oral and mental starters of their lessons, mainly for recall and reinforcement of number facts and often using the IWB. Saba, having mentioned using the IWB for lots of games, nevertheless questioned whether pupils were 'actually learning what they're supposed to' (NTInt.Saba

11/06), if they played too many games. Now established teachers, it seemed they no longer associated the more serious business of teaching and learning, particularly in the main part of the lesson, with having fun and enjoying mathematics, as Freddie comments; 'the games and stuff may be fun but they have to settle down and work now, just get on with it' (NTInt.Freddie 11/06).

As teachers they also considered the need for tangible evidence of learning more important than open-ended games and activities. Harry's claim that with SATs and targets, 'there's a constant demand for evidence of their levels so we do more written exercises than I would choose' (NTInt Harry 12/06), was reiterated by Freddie and also by Mags who said:

> 'I like to see it written down in their books ... you need that evidence of what they've done ... if they spend too much time playing with the things and not working – or writing it, how do I know they've learnt anything' (NTInt.Mags 11/06).

Their earlier belief that pupils should enjoy mathematics and find it fun, evident from their Initial Study questionnaires had been superseded by their perceived need for tangible evidence of their teaching and pupils' learning, seemingly only expressed in written form.

Inclusion of questioning

When interviewed all four teachers made spontaneous reference to open and closed questioning. Mags professed for her, questioning had become an automatic feature, through further probing however, she revealed the majority of her questioning was closed and teacher directed. She suggested this was something she needed to think further about, aware she had not progressed beyond her earlier practice, tending to use closed questions of low cognitive demand to recall and revise knowledge. Saba also inclined towards closed questions, directions and instructions, admitting:

> I'll say 'tell me how you did that' but there's not time really, not to find out why they chose that way or if another way might be better... I'm mainly sort of explaining and telling them what they're to do and how to do things (NTInt.Saba 11/06).

Freddie described using a mixture of open and closed questions to 'get children thinking', but on further probing acknowledged his open questions were asking pupils to demonstrate how they worked out a closed problem, usually taken from SAT papers. Harry similarly claimed to use a mixture of questions, asking children about different ways to obtain the right answers, for example 'how would you find out...? What else might you do...?' (NTInt.Harry 12/06) but he too referred to the need to practice worded number problems, particularly SAT questions.

It seems these new teachers, driven by the demands of SATs, made little use of open, cognitively demanding questions, instead focusing on closed questions requiring simple responses, and rarely following up pupils' responses or extending their thinking. The apparent progress made over their two placements as students, seems to have been superseded by the demands of SAT preparation. The practice of these teachers echoes Moyles et al's observation that teachers, 'rarely extended pupils' responses or challenged their thinking (Moyles et al 2003 p.178) and Smith et al's observation that 'teachers spent the majority of their time either explaining or using highly structured question and answer sequences' (Smith et al 2004 p.408). There is also support for Myhill's (2006) claim that 'teachers' questioning … remains heavily directed towards factual and closed responses (p.27).

Inclusion of discussion

All four new teachers showed a greater focus on paired discussions and group work in mathematics lessons, than as students. Saba acknowledged discussion enabled her pupils to share and develop their ideas, noting they 'work very well together and … can really get good ideas and feed off each other' (NTInt.Saba 11/06). Mags, attempting to encapsulate her ideas of interactive teaching, similarly focused on participation and the two-way process of learning, sharing ideas and clarifying misunderstandings. Notwithstanding this positive view of discussion, I noted in my observations both Mags' and Saba's discussions were heavily teacher directed, focusing mainly on recall of number facts and processes, or working out answers to closed questions in preparation for SATs, rather than exploring different mathematical ideas and extending pupils' thinking.

Inclusion of creative, investigative problem-solving

Investigative and creative problem-solving, particularly through collaborative group work, remained the least developed aspect for these new teachers, all referring to its absence in their teaching. Freddie used SAT worded number problems for 'investigation', these being closed questions, where pupils merely identified the method of calculation. Freddie acknowledged these were not open-ended activities, that would further pupils' higher-order thinking, but, justified this by saying although open-ended activities were fun, challenging and got children thinking, 'they're not in the tests and that's what I've got to concentrate on' (NTInt.Freddie 12/06). Saba similarly used practice SAT questions for worded number problems, whilst Harry admitted he also did very little investigative work, as there was no time with so much else to cover. Once again, opportunities to develop pupils' mathematical understanding and scaffold their learning, through cognitively demanding questions and investigations that challenge and extend their thinking, seem to have been superseded by the demands of a testing regime focused on pupils' knowledge of rules and procedures.

Factors influencing new teachers' implementation of interactive teaching

Interviews with the four new teachers also addressed the internal and external factors they perceived as influencing their implementation of interactive teaching (NTInt questions *App.6.3*). Discussion of their responses and perceptions follows.

Internal Factors

Knowledge

Gaps in their subject knowledge and pedagogic content knowledge continued to raise concerns for new teachers. Saba was particularly concerned about her ability to scaffold pupils' learning through questioning and explanations, as she explains:

> I need to know more ways of being able to draw things out of them … I think I find myself getting a bit stuck and then explaining things in the same way and not knowing how to develop it (NTInt.Saba 11/06).

Freddie continued to be challenged by new methods and processes he had not experienced himself, noting, 'I'm still finding it hard to teach the new ways of doing things, like using the grid method, numberlines, partitioning, stuff like that' (NTInt.Freddie 12/06). Mags also acknowledged the same challenge, in particular her reluctance to use practical materials to support children's learning. Such insecurity meant these new teachers, still lacking confidence in their own pedagogic subject knowledge, and still learning to teach unfamiliar methods with confidence, would likely struggle to extend pupils' thinking through challenging questions or creative problem-solving. Shulman (1986) has stressed the need for teachers to have 'a veritable armament of alternative forms of representation' which, he suggests 'derive from research (and) the wisdom of practice' (Pollard 2002 p.153). These new teachers would need time and opportunity to gain both.

Fear

Although there were few acknowledgements of fear at this stage, there were some concerns for teachers in establishing their role and identity in a new and unfamiliar environment, and having to make their own choices and decisions. There was a sense of isolation, and, as Freddie said, the feeling that 'you're on your own' (NTInt.Freddie 12/06). Harry had similar worries saying, 'it's easy to get it wrong – it's quite isolating really when everyone else just seems to know and gets on with it' (NTInt.Harry 12/06). The feeling that other teachers knew so much more left new teachers worried their lack of experience would be noticed, evidenced also in how well they managed pupils' behaviour. As NQTs they were concerned to establish their control at the beginning, leading them to adopt a teacher directed, didactic approach. As Harry recalled:

> When I started ... I wanted to have control, set the rules and so on, I wanted to establish quiet working, no calling out etc. so I did find I went back to explaining what I wanted them to do and then getting them working on their own (NTInt.Harry 12/06).

Freddie expressed similar concerns, commenting on his headteacher's expectation of effective control and management, whilst Mags' feared her pupils would not learn unless she kept a tight hold on what they were doing.

These concerns centred around new teachers' lack of knowledge and experience, which they worried would be evident if they lacked control and management of their pupils, and most felt increased noise levels would suggest this. As Denscombe notes, 'noise emanating from classrooms carries with it connotations of a lack of control ... and a certain lack of competence on the part of the teacher' (Delamont 1994 p.136). This fear of being seen as incompetent by experienced staff led new teachers to be more controlling and directive than they believed they would be at the beginning of the PGCE course.

External Factors

Role Model

This was less of an influencing factor for new teachers who had fewer opportunities to work alongside other teachers, and observe fellow practitioners as possible role models. Mags highlighted this with her comment; 'I don't know whether it's right … you're pretty cocooned now and don't get the opportunity to see how others do it' (NTObs.Mags 11/06). This sense of uncertainty left these new teachers doubting their ability and added to the sense of isolation they felt as the least experienced newcomers. What influence there was, came from implicit messages picked up by new teachers in staffroom discussions, where comments made about noise levels and children's behaviour suggested expectations for all.

Teacher guidance and direction

Once qualified, these teachers found their new level of autonomy and responsibility meant less guidance and reassurance from experienced teachers. Being responsible for their own classes and the teaching and learning within these, they were no longer under the close direction of another teacher. They were now expected to make their own decisions about the content of their lessons and teaching approach. For most NQTs, this had provoked feelings of uncertainty, Harry commenting, 'it's so good to be able to set things up the way you want to, but it was quite worrying too as there was no-one there to say perhaps you ought to try this or I don't think that's going to work – you just have to have a go' (NTInt.Harry 12/06).

Nevertheless, it seemed their limited experience and desire to fit into their new school community led them to comply with the perceived expectations of other members of staff. Saba, taking a mathematics group that included pupils from a colleague's class, was conscious of trying meet his expectations. She explains:

> I'm trying to make sure I really get across what I'm supposed to do rather than going outside the box a little bit - it's hard to ... do what I want to do really' (NTInt.Saba 11/06).

Nevertheless she appeared to benefit from her colleague's expertise, appreciating his enthusiasm and good ideas which she could adopt.

Freddie and Harry both stressed the lack of freedom in having to follow the year group's plans, which rarely including creative, investigative problem-solving, both noting the importance of covering everything on the Primary National Strategy (PNS) unit plans. As Freddie remarked, 'you're not as free as you think you're going to be' (NTInt.Freddie 12/06).

New teachers still sought the approval, support and guidance of more experienced teachers to help build their confidence and knowledge, whilst continuing to develop expertise in knowledge and practice in teaching mathematics, also influenced by their beliefs, views and established practice.

Standard Assessment Tests

The pressure of SATs appeared a particularly influential factor for new teachers. All four interviewed made reference to the importance of ensuring children were prepared well for

SATs. Getting good SAT results appeared a strong driving force and constrained what and how they taught. Saba experienced these pressures even though working with year 5, who had a further year before taking Key Stage 2 SATs, commenting, 'we're already priming them for their SATs in year 6 and it's a real drive in year 5 to get them used to the vocab. in the questions in the SAT papers' (NTInt.Saba 11/06). Mags made similar reference to this preparation and, as discussed previously *[p.170]*, new teachers use of open, cognitively challenging questions and investigative problem-solving appeared to be constrained by the demands and expectations of regulatory testing. Thompson's (2001) concern that testing had become a more important focus than the learning itself seems borne out by these new teachers' experiences and 'what you test' is indeed 'what you get' (Ruthven 1993 p. 433).

Time and Pace

New teachers did not make reference to pace in interviews, but pressure of time continued to impact on their teaching. With felt pressure to complete each topic within the NSS allocated time and move onto the next, there remained a tendency to resort to an element of rote learning or instrumental understanding, rather than deeper relational understanding (Skemp 1976). As Mags pointed out:

> the time is limited, after so many days you have to say, actually bottom line is it's this and maybe they'll have an opportunity when they get to secondary school for thinking more – it's not that I'm jumping the why but come day five on fractions they've got to know how to do it' (NTInt.Mags 11/06).

Saba and Harry made similar comments, whilst Freddie added 'You can't just keep on trying to get them to understand, sometimes it's just, this is what you have to do – learn it – there isn't the time to play around with it' (NTInt.Freddie 12/06). From this evidence, it appears pupils' understanding in mathematics is being sacrificed to ensure shallow coverage of a wide range of topics, and mechanistic approaches to learning are seen to support the answering of SAT questions.

Once qualified, with their own class and more independence and autonomy, new teachers were eager to develop their own style and approach to teaching mathematics, no longer constrained by their classteacher's plans, style of teaching or expectations. Nevertheless, data show interactive aspects of their teaching had not developed significantly during their first year as teachers. As new teachers, all four tended towards a didactic style in mathematics, and made limited use of cognitively challenging aspects of interactive teaching and learning, echoing the findings of Moyle et al (2003), Smith et al (2004) and Burns & Myhill (2004) in their studies of experienced teachers. These new teachers all considered the pressures of SATs, and demands for written evidence of pupils' learning, limited their choice of content and teaching approach. The continued demand to reach ever-higher targets in SATs seemed to lead teachers towards didactic and mechanistic teaching, which precluded development of pupils' higher-order, creative thinking, particularly as such thinking is not required to answer the majority of SAT questions. Harlen et al's (2002) observation that there is an over-emphasis on revision and rote-learning in order that pupils perform well in SATs seems borne out by these findings.

Through their PGCE course placements these students could be seen to progress through Fuller & Bown's (1975) three stages of development, focusing firstly on survival and their own teaching, then pupil concerns, and finally into Furlong & Maynard's (1995) moving on stage. Lacking in confidence and competence at the start, their focus was on themselves and their delivery of lessons, reliant on their classteachers' direction and modelling. As they extended their subject and pedagogic subject knowledge and grew in confidence, their focus moved to the pupils and the deeper, cognitively demanding aspects of interactive teaching. Once qualified however, their progress was impeded by the demand for good pupil control, good SAT results and imposed targets. My study shows the Government's insistence on meeting ever-higher targets, and NSS demands for whole-class teaching with pace and urgency, has driven new teachers back to traditional, didactic teaching of rules and processes, heavily weighted towards SATs questions. This echoes Moyles et al (2003), Smith et al (2004) and Burns & Myhill (2004) studies of experienced teachers and raises questions about the impact ITE has on students who, once qualified, resort to the seemingly safe practice learned from experienced teachers. In the final chapter I discuss this further, drawing together the findings of the study, and exploring the implications for ITE and research in mathematics education.

5

Discussion of Findings

In this chapter, I draw together the findings of my study and present three conclusions in response to the research questions. I consider the implications of these, the contribution my study makes to research in mathematics education and initial teacher education, and present a critical evaluation of the study. In the final section, I provide a personal reflection and consider implications for further professional development.

My research aim was to explore the development of student teachers as professionals, within the context of a university/school partnership and the constraints of government objectives and school culture. My specific focus was students' interpretation and implementation of interactive teaching in mathematics, and factors that influenced this, and the particular research questions I posed were:

1. What are students' views of, and approaches to learning?
2. What was the structure and teaching approach of mathematics lessons students experienced as pupils?
3. What were their attitudes to, and feelings about mathematics at the beginning of their PGCE course?
4. What did students perceive to be the key features of interactive teaching?

5. Did students include the key features of interactive teaching: active involvement of pupils, the use of questioning and intervention in scaffolding pupils' learning; the use of discussion and collaborative group work and creative problem-solving, in their own teaching in school placements?
6. How do internal or personal elements influence students' inclusion of key features of interactive teaching?
7. How do external or social context elements influence students' inclusion of key features of interactive teaching?

In an initial study, I explored the first four questions; students' prior experiences, views and beliefs about mathematics and their developing understanding and interpretation of interactive teaching. This guided and informed the main study, which explored students' scaffolding of pupils' learning through use of interactive teaching, specifically their use of; pupils' active involvement; questioning; discussion and collaborative, creative problem-solving, and considered aspects of the ITE experience which facilitated or constrained this.

Discussion

At the beginning of this study *[p.7]*, three key elements were highlighted, identified by Ernest (1989 p.249) as influencing the kind of teacher students become:

- their mental schemas
- the social context of their teaching environment
- reflexivity.

These three elements were represented within the Social Context of Learning model *[Fig.2 p.43]*, providing a lens through which students' developing knowledge, understanding and practice could be viewed. As novice teachers, students' previous experiences, and the beliefs and ideas they held about mathematics teaching, often left them unaware of the limits of their competence and the complexity and challenge of teaching. Providing a challenging and inquiring environment, that encouraged critical reflection and scaffolded their learning, was important in enabling students to progress along the continuum from novice to expert.

My exploration of students' interpretation and implementation of interactive teaching began with a belief in learning as a shared endeavour, with knowledge constructed through experience and social interaction within social and cultural communities (Loughran & Russell 1997). Findings suggest that students' stage of competency and the influence of university, school communities and government directives, had an impact on their engagement with particular features of interactive teaching in mathematics.

Students' development as teachers cannot be seen as a simple progression in individual skills, knowledge and understanding, built on practice and experience, but as a constant interweaving of individual interpretation, socio-cultural influences and practice. Ernest's three elements therefore, provided a helpful framework in drawing together and discussing my findings. I considered students' learning in the social arenas of the university and school to be mediated by their individual mental schemas. Hence, in the discussion to follow, I view the individual element from within these two social contexts.

The Individual within the University Context: students' knowledge and beliefs about the nature, teaching and learning of mathematics

Initial Study data challenged one initial assumption I held; that although some students would have experienced a didactic, transmission-based approach to teaching as pupils, as products of the Plowden and Cockcroft teaching reforms, most would have experienced more individualised, practical and discursive teaching, upon which I could build. This, however, was not the case; a very high percentage recalled didactic, transmission-based teaching, the majority expressing a negative view of mathematics. This was consistent with Brown et al's (1999) account of their students' experiences, and their report that 80% 'disliked mathematics or found it a struggle' (p.305). I was aware of claims made by Tabachnick & Ziechner (1984) and Grossman et al (1989) that little change in students' beliefs and views of mathematics was likely and students were most likely to teach as they were taught themselves. Additionally, the images students have of their experiences as pupils have a powerful influence on their own teaching (Ball 1988; Calderhead & Robson 1991; Carre and Ernest 1993), findings my study sought to confirm or refute.

Findings from my Initial Study showed widespread anxiety about mathematics amongst students; their previous experiences as pupils, their levels of knowledge and understanding and the prospect of teaching mathematics themselves given as reasons for this. Opportunities for students to explore and extend their mathematics and pedagogic subject knowledge, through discussion and debate, in the constructivist approach adopted in university sessions, seemed to alleviate many of these concerns. Although, as Russell

(1988) and Carter (1990) note, beginning teachers often consider their classroom-based practice to be the most significant aspect of their teacher education courses and a major influence on their development, it was clear these students felt the university element had a significant impact. Their attitudes and feelings about mathematics had changed by the end of the course and the majority attributed this to the university-based aspect of the course. As data from post hoc reflections showed *[p.154]*, 87% of students claimed university sessions had been the strongest influence on their ideas about teaching, challenging their previous experiences and views and giving them much more confidence and liking for mathematics.

These findings concur with Bramald et al (1995) and Brown et al (1999) in concluding that belief systems are not as resistant to change as previous research indicated, and that mathematics courses in ITE can modify primary students' negative attitudes to mathematics, by providing opportunities for them to debate and discuss their own experiences and views of mathematics. This suggests ITE programmes would benefit from giving further attention to developing positive attitudes towards mathematics, and for this to continue beyond students' initial teacher education to ensure confident, enthusiastic mathematics teachers.

What became apparent from data, was the drive for students to try out new or different ideas and approaches, introduced in university sessions, in their lessons, was counterbalanced by diverse constraints, emanating from within themselves (internal) and their school context (external). The practice they adopted depended on the competing strengths of these driving forces and constraints, as represented by Lewin's model of Force

Field Analysis (Schein 1995) *[Fig.4 p.53]*. If the restraining forces were stronger than the driving forces then, for students in my study, little change from didactic transmission-of-knowledge teaching would be seen in their practice. This appeared to be the case, both internal and external constraints seemingly stronger forces than the drive of university input.

Analysis of my findings led to three key conclusions discussed below.

1. ***Students' individual understanding and interpretation of interactive teaching is scaffolded, through a constructivist process of discussion, collaboration and reflection.***

University sessions in mathematics provided students with, 'opportunities for testing, discussing, and comparing various perspectives and approaches to teaching' Richardson (1997 p.51). This inquiry or investigative approach to mathematics teaching epitomises a constructivist perspective, in offering challenges that stimulate students' mathematical thinking, and create opportunities for critical reflection of mathematical understanding (Cobb et al 1990). The aim was to persuade students to go beyond the rule-driven, procedural understanding of mathematics the majority seemed to hold, towards conceptual and relational understanding (Skemp, 1976; Edwards & Mercer, 1987), and beyond the didactic, knowledge transmission view of teaching to a learner-focused approach. Evidence indicates this was a successful approach, as this student's response suggests:

> I now see maths as being much more of an experimentally based subject, and mathematical proof as being often inductive rather than logical/deductive. I

> have come to enjoy teaching maths, which I suppose I initially saw as a challenging subject with hidden perils known only to the enlightened. ... I think it is most important, as a teacher, to generate a non-threatening environment - a sense of investigating the subject together - and to encourage pupils' methodology in the first place, with accuracy of results a pleasing conclusion (04M10 07/05).

Within a constructivist environment, individuals construct their own understanding, mediated by their previous beliefs, knowledge and experience. From group discussions in university sessions, students came to share a seemingly common view of interactive teaching. It became apparent however, that as individuals they held somewhat different perceptions. One indication was Mags' agreement, in discussion with her group, on the value of cognitively demanding questions. In a later interview however, (FSInt Mags 01/05) she described questioning as checking knowledge of facts, rules and procedures. I could make no assumption that all students had come to share and commit to a common understanding of interactive teaching, as their later practice and discussions confirmed.

It became clear that some students struggled to escape from the impact of previous mathematics' experiences that privileged procedural knowledge, or instrumental understanding, over conceptual knowledge (Skemp 1976). A few held tenaciously to their beliefs about the nature of mathematics and how it should be taught, notably Mags and Freddie, perhaps because the model of teaching they experienced reinforced this, or acknowledging the limits of their mathematical knowledge and understanding presented too great a challenge.

Reflexivity

The metacognitive skills students developed through weekly discussion and collaborative activities in university sessions, and their evolving interpretation of interactive teaching were important to their developing expertise. As the course progressed, students showed greater awareness of their strengths and weaknesses, beliefs and assumptions, and learning strategies. Desforges (2001) considered such metacognitive activity to be the main driver in students' development from novice to expert, ensuring conscious and deliberate practice. My study shows that, as students' self-awareness developed, they became more considered in their thinking, actions and decisions in the classroom (Brown 1997). Paul demonstrated this thoughtfulness when reflecting on the approach to teaching he wanted to adopt:

> How I learnt it was very dry and silent … so very didactic. I know I don't want the kids I teach to see maths as something boring or frightening. I don't want them scared to get things wrong – it's made me hate maths … we've had all these fun ideas and I've learned better that way, and I'm hoping that I can be somebody who can embrace those' (FSInt.Paul 01/05).

My observations of discussions and activities in university sessions suggested these novice teachers were beginning to build the subject and pedagogic knowledge and self-awareness, key to developing teacher expertise (Initial Study 10/04). As Pintrich (2002) noted, talking aloud about their own cognitive processes as they worked through mathematics problems, and discussing their choice of particular strategies, helped students make their implicit knowledge explicit. Such interactions within the group, evident in the Initial Study, encouraged questioning, critical reflection and inquiry. Through strengthening the relationships within groups, this community of inquiry provided a safety net that, to some extent, helped lessen the students' sense of deskilling and loss of confidence that Atherton (2003) claimed to be synonymous with their shift to the conscious incompetence phase.

As students continued to reflect on, monitor and evaluate their progress in school, the cultural norms and established practices of the school, and the expert teacher who guided and supported them, all influenced their practice. My findings indicate that, in their first practice, students demonstrated many of the characteristics of novice teachers in the conscious incompetence phase. Becoming aware of the limitations of their subject and pedagogic knowledge, they were often anxious and lacking in confidence, concerned particularly about managing the pupils.

These findings led to the second and third conclusions.

2. ***In the early stages of development as novice teachers, students' implementation of cognitively demanding aspects of interactive teaching in mathematics is constrained by individual mental schemas, or internal factors.***

As Askew et al (1997) found in their study of effective teachers of mathematics, expert teachers need 'pedagogic content knowledge' (Shulman 1986), incorporating three elements: understanding of the knowledge appropriate to what is being taught; knowledge of how pupils learn mathematics; and understanding of different teaching approaches for presenting information to pupils. Data from my study suggests those elements were at an early developmental stage for the majority of students. As they became conscious of their incompetence in these knowledge areas and the practical experience of teaching, so their confidence plummeted (Atherton 2003). Elements of Fuller & Bown's (1975) and Furlong & Maynard's (1995) survival stage were evident. Data from the first school practice showed students aiming to 'just get through' these early days, keeping pupils on task and under control. At this stage they retained an inward focus, concentrating on class management and their own performance. This was evidenced in students' first school practice interviews (FSInt 11/04 & 01/05), by their dependence on prepared plans, set strategies and directives to which they tended to adhere rigidly, and their focus on delivering content, through a mainly didactic approach.

Looking closely at features of interactive teaching used in early stages of students' teaching, this focus on self and survival, could begin to explain their concentration on pupils' physical and practical engagement in mathematics lessons. This was a tangible aspect, specifically detailed in lesson plans, with instructions easily followed and delivered, and over which students felt they had some control. Students had evidence that pupils were actively engaged and working, supporting the conviction that they were teaching, and pupils must be learning.

Student interviews during the first placement showed they often attributed their limited use of open, higher-order questioning and discussion to fear of losing control of the class, or having insufficient mathematical knowledge to extend pupils' thinking (e.g. FSInt.Jared 11/04). Questioning and discussion that made higher cognitive demands on pupils required characteristics that, as novices, these students had not yet developed. They needed to be able to assess pupils' levels of knowledge and understanding, thus identifying their needs and abilities. They also had to focus on pupils' responses, rather than their own delivery and have sufficient knowledge and confidence in mathematics to move away from rigid plans or their classteacher's expectations, characteristics that, as Fuller & Bown (1975) and Furlong & Maynard (1995) explain, develop later in their journey towards competence. Lacking these skills, students also lacked confidence in using cognitively demanding questions and discussion, or developing creative problem-solving and investigative activities. Berliner's (1988 p.2) description of a novice teacher as, 'rational, relatively inflexible and tends to conform to whatever rules and procedures they were told to follow', seems to apply to these students. In their first practice, without the knowledge, experience and confidence to make their own considered choices and decisions, students, as Saba typifies *[p.130,]* sought clear, specific guidance and instructions from their classteachers and mentors.

Progression through the year saw most students move gradually into the conscious competence stage. Having reflected on earlier experiences and extended their subject and pedagogical knowledge, they were able to make more conscious and considered choices about their later practice. From observations and interviews during the final practice, I found students more willing to move away from rigid lesson plans when able to do so, and responding more flexibly to pupils' perceived needs (FPInt Freddie 06/05). They had a wider repertoire of strategies upon which to draw and were more aware of successful strategies for managing behaviour.

Feeling more confident and in control of events, they took increasing responsibility for pupils' learning and behaviour. This progress in teaching skills was reflected in students' more sophisticated use of open, cognitively demanding questioning and increased, albeit still limited, use of discussion in mathematics lessons. As they reached Fuller & Bown's (1975) 'pupil concerns' stage in their development as teachers; more confident and competent and able to focus outside their own performance, students were ready to extend their thinking and incorporate the cognitively demanding aspects of interactive teaching. As they developed their higher order skills and knowledge needed to extend pupils' thinking, they began to use higher order questioning and discussion, and, where encouraged by classteachers, include cognitively demanding problem-solving and investigative activities in their teaching.

These skills had been fostered in university sessions, through reflection and discussion and students needed continued support and scaffolding whilst in school. As my discussions and interviews with students show, this was rarely available and students felt challenged and constrained by teacher and school expectations, the teaching approaches favoured and demands made by national assessment and testing. This led to my third key conclusion.

Socialisation into existing cultures and practices of schools, often mlitates against students and new teachers developing the cognitively demanding aspects of interactive teaching; those that privilege conceptual knowledge and understanding over procedural knowledge.

As novices, students and new teachers were in the process of establishing their identities as teachers, aware of needing to follow their schools' rules, rituals and routines and keen to engage as professionals with teacher talk in staffrooms. This aim to fit into school culture, which Lave & Wenger (1991) term enculturation, supports, but also constrains students' development, McNamara et al (2002 p.53) noting, 'socialisation into existing cultures and practices can be seen to perpetuate *ineffective* practices in teaching'. Alexander et al (1992 p.53) offered a similar observation of 'some schools merely recycling their inadequacies'. Certainly, in terms of developing effective interactive teaching and learning in mathematics, I found this to be true for many students. The practice modelled by teachers tended towards a didactic transmission style, as studies by Moyles et al (2003), Smith et al (2004) and Myhill (2006) also indicated. Rather than developing effective interactive teaching, I found many students returned to this familiar didactic teaching style, modelled in classrooms, which the majority experienced as pupils, even when this contradicted their previously expressed views of effective mathematics teaching.

The directed, top-down, prescriptive nature of the NSS framework and associated SATs, has removed teachers' and schools' autonomy in deciding how to design, plan, deliver and assess the mathematics curriculum. This lack of autonomy has resulted in a tendency for schools to follow directed, narrow, test driven mathematics schemes, rather than design less routine, open-ended tasks that would develop higher level thinking and reasoning skills (McGuiness 1999). Additionally, teachers are constrained by their own school culture, sets of practices, assumptions and expectations as well as bringing to the situation, as Denscombe (1984) notes, 'expectations from their personal biography' (p.145). This then brings into question a claim by Ruthven that:

> if expertise resides in the situated thinking and performance of experienced practitioners and is best developed through exposure to this, then where better for novices to learn to teach than in school, through observation and experience under the guidance of experts in the craft of teaching (1993 p.3).

There is little doubt, as Berliner (1986) has suggested, that students can learn from their experience in schools and benefit from working alongside experienced practitioners, who scaffold their learning through dialogue and discussion. However, Alexander et al (1992) and McNamara et al (2002) have pointed out that too often this is not the case. As research shows mentor/student discussions tend to focus on organisational features of lessons, rarely addressing specific mathematical aspects or engaging in deeper philosophical discussions (Brown et al 1999). If expert teachers have little clear understanding of interactive teaching themselves, and continue to adopt didactic approaches to teaching mathematics, as Moyles et al (2003), Smith et al (2004) and Myhill's (2006) research show, then, as my study highlights, students are most likely to adopt a similar approach.

Educational Implications

At the time of writing, the NNS, now incorporated within the Primary National Strategy (PNS), has been established in primary schools for ten years. Since 1999, schools have adapted and developed their mathematics curriculum, class organisation and teaching approaches in accordance with PNS guidelines. The SATs are seen as a way of checking whether standards have risen since that time, and OfSTED has monitored NNS effectiveness within the classroom. Through my study, I found very little change in the way mathematics is viewed, taught or assessed. Students continue to adopt the approach modelled in schools, too often similar to the didactic, teacher directed style experienced as pupils. In primary classrooms, as OfSTED (2008) reports, there remains a focus on the teaching of number facts, rules and procedures through a direct, instructional, transmission approach. As researchers such as Brown et al (1999); Moyles et al (2003); Smith et al (2004) and Myhill (2006) show, and confirmed by my study, this relies on rapid, closed and cognitively undemanding questions, generally presented to the whole class, followed by individual work from worksheets or textbooks. The use of collaborative group work and discussion, and of open-ended investigative problem-solving appears to be limited to a few schools who value children's creative mathematical thinking. Noss presents a now familiar argument, referring to the de-skilling of the mathematics curriculum through over emphasis on basic arithmetic, noting that:

> Even in 1982 ... some raised their voices in favour of a wider and more demanding mathematical diet, and the necessary school practices which would prepare employees for collaborative work, understanding and creativity (Noss 1997 p.10).

Reynolds in the Times Educational Supplement (1997) echoed this need for school practices that would prepare employees for the collaborative work, understanding and creativity, now seen in the Pacific Rim countries. He also expressed concerns about whole-class teaching:

> whole-class teaching is now agreed to involve costs for the extremes of the achievement range, since teachers have to teach 'to the middle'. While the less able may be caught up, the more able remain unstimulated. Situations where there is high control over children's learning may not produce children who can work independently. They may discourage the generation of new ideas and creativity which may not be easy to achieve in such ordered settings. Children who are used to working in one large group are unused to the collaborative small group work that modern industrialists want (TES 27/6/1997).

Nevertheless, the NNS went ahead with increased whole-class teaching and it is evident that creative and collaborative aspects of mathematics teaching and learning focusing on conceptual understanding, have been ignored in favour of preparing pupils for SATs. As I found in my study, attempts to foster creative collaborative approaches have been less than successful and students found it difficult to put such ideas into practice faced with constraints in schools.

The NNS was revised in 2006 (DfES 2006), with attempts made to reduce the prescription of the previous framework. Problem-solving was 'embedded into the broader strand of using and applying mathematics' (DfES 2006 p.65) but still tended to focus on the one or two-step number problems featured in SAT papers, failing to address the lack of creative investigative activities. It was suggested in the NNS however, that links be made between curriculum subjects to deepen children's understanding, by 'providing opportunities for application of knowledge in new contexts to involve children in higher-order thinking skills, such as reasoning and problem solving' (DfES 2006 p.13). Creative thinking, they suggested, comes when children 'identify patterns in shapes and relationships between numbers' (DfES 2006 p.120), which seems a somewhat narrow view of creative mathematical thinking.

The most recent OfSTED Report, 'Mathematics: understanding the score' (Sept. 2008 p.4) also suggests that, in practice, little has changed. It records a continued 'heavy emphasis on "teaching to the test", noting that, 'pupils had too few opportunities to use and apply mathematics, to make connections across different areas of the subject and extend their reasoning', noting that 'links with other subjects were insufficient' (p.6).

Demands for changes in the teaching of mathematics continue and are long overdue. Joyce (1992), reiterated by Moyles (2003), contends that if they are to make changes in their practice, teachers need:

> extended opportunities to think through new ideas and to try out new practices, ideally in a context where they can get feedback from a more expert practitioner and continue to refine their practice in collaboration with colleagues (Smith et al 2003 p.409).

Student teachers similarly depend on such opportunities in their partnership schools, raising the question of who is able to provide this if teachers themselves do not have such support. This has implications for educators and schools, in developing the subject and pedagogical knowledge of their teachers, their expectations of students in the classroom, and the support students need at different stages of their practice (Furlong & Maynard 1995).

My study shows that it is possible to change students' perceptions of mathematics and offer alternative approaches to teaching that foster interactivity. This addresses OfSTED's recommendation for 'mathematics-specific pedagogy to aid the development of pupils' understanding', and 'teaching approaches and activities that promote pupils' understanding' (2008 p.8). However, if students are to implement these effectively in the classroom the importance of experiencing such approaches and seeing them modelled at university and in schools is evident. Staying true to the constructivist perspective that permeates this study, students, although not initially able to adopt such approaches independently, benefit from scaffolding and support from a more knowledgeable other, usually their mentor in school, until able to master this alone. Classteachers and mentors in school thus require an awareness of students' developmental stages, and sufficient in-depth subject and pedagogic knowledge, to enable them to use effective questioning to scaffold students' learning and move them towards independence in teaching, as they would support and guide pupils' learning. Such knowledge would also enable them to engage with students in reflective professional discussion and informed debate about effective teaching and learning in mathematics.

The recent William's Review (2008) and OfSTED report (2008) have highlighted the need to improve teachers' mathematics subject and pedagogical knowledge, which would aid 'the development of pupils' understanding' (OfSTED 2008 p.7) and enhance the role of subject leaders for mathematics. Additionally, for schools to:

> provide well targeted professional development in mathematics, particularly to improve teachers' subject-specific pedagogy and the subject knowledge of non-specialist teachers of mathematics (OfSTED 2008 p.8).

The authors of these reports suggest further attention be given to teachers' professional development in mathematics. As Moyles' (2003) showed, unless this focuses on key aspects of interactive teaching and learning, and time and opportunity are given for teachers to reflect on and refine their practice in collaboration with colleagues, little is likely to change.

Additionally, unless assessment and testing focuses less on meeting government prescribed targets and on setting schools against one another in some kind of competition that encourages schools to 'teach to the tests'. And unless assessment and testing focuses less on recall of facts and rules and more on pupils' conceptual understanding, collaboration and creative problem solving, then instrumental understanding will continue to dominate mathematics teaching.

Initial Teacher Education: The PGCE Programme

My study raised questions related to the PGCE mathematics programme and the teaching approach modelled within it. Although I took for granted what I believed to be a constructivist approach, subsequent reflection suggested that this was not always clearly manifest in my practice. There are difficulties in maintaining a constructivist approach whilst presenting a prescribed strategy, such as that promoted by the NNS to students, and although I did not adopt a didactic style, there were elements of telling and instructing within sessions that could be questioned. O'Reilley (Loughran & Russell 1997 p.169) points out:

> We do need to examine our teaching practice. ...We have a lot to tell our students, but I believe our primary job should be to bring them to asking, by whatever means we can devise, the questions that will elicit what they need to know.

One of my aims in reviewing the PGCE course is to extend students' subject and pedagogical knowledge, through further development of a personalised, questioning approach that will encourage them to ask such questions, and wider use of collaborative group work and creative problem-solving. Through experience of well-modelled example and reflection, students may come to recognise the value of these elements and, with more confidence, feel able to include them in their teaching. A further aim is to encourage students to focus on pupil concerns, through the use of scenarios and vignettes, which look closely at pupils' responses, what these indicate in understanding and misconceptions, and how pupils' thinking can be furthered and extended through their focused questioning, so modelling effective scaffolding.

School Partnership

Students' experience in partnership schools is another aspect to be reviewed in light of this study. It is difficult to influence the approach to teaching and learning mathematics modelled within schools, other than through working alongside classteachers and through relevant professional development and mentor training programmes. What may be appropriate is to develop a more collaborative partnership between university and schools that recognises and develops the important role schools play in student teachers' education. As Calderhead & Shorrocks (1997) suggest, school's responsiveness to students' stages of development and individual needs is likely to be a major determinant in their learning and development. This role cannot be reduced to mentors in schools 'giving the student the skills' of teaching, as the DES (1983 p.10) suggests. Experience and research has shown that such transmission models do not work (Haggarty 1995; Alexander 2004b; 2006). Based on findings from my study, I suggest that students need to learn to teach mathematics alongside their classteachers, through scaffolded learning. This would build on students' current knowledge and understanding, and support them through the stages from novice to expert, whilst recognising the particular focus and needs of each stage (Furlong & Maynard 1995). Working in partnership with schools to develop a shared understanding of an effective learning experience for novice teachers would, I believe, be a valuable development.

A further consideration would be to extend university-based support to the students' Induction Year as newly-qualified teachers. This would provide some continuity and consistency, and a forum for continued reflection, discussion and debate as NQTs struggle to adapt to the new structures, philosophy and practice of their first post. It would provide NQTs with further scaffolding to benefit their continuing learning journey towards becoming an expert teacher and help to consolidate the still tentative subject and pedagogic knowledge and experiences gained during their initial training year. Whatever recommendations are made for changes in university programmes it remains imperative that mathematics teaching in schools should model and guide students in effective practice that incorporates high quality discussion, questioning and creative problem-solving. This has implications for teachers' continued professional development in mathematics teaching and learning, a further concern raised in both the William's Review and OfSTED's report.

Contribution to mathematics education research

My research contributes to current theoretical understanding of teaching and learning mathematics in its consideration of how students' learn to teach mathematics. I add to the work of Grossman et al (1989) and Bennett & Carre, (1993), providing evidence that students' initial views, beliefs and attitudes to mathematics can be changed within a constructivist approach to students' learning and that debate and discussion must continue as part of teachers' professional development if such changes are to be sustained. The conflicts and constraints students experience in implementing interactive teaching raise some concerns about the influence of school practice on students' development as teachers. Current models of mathematics teaching within schools clearly tend towards a transmission approach, supporting the current test and target-driven view of teaching and learning. As students are strongly influenced by the school context and the practice they observe, and because schools are being encouraged to take increased responsibility for teacher 'training', questions can be raised about the future role of both schools and higher education institutes in the education of student teachers.

Research (Myhill 2006; Hardy 2007; Watson 2007) continues to address effective teaching and learning of mathematics, challenging the narrow utilitarian view that seems to dominate policy and practice. My study contributes to that debate in highlighting the lack of creative and collaborative approaches in schools, and the difficulties for students and new teachers in initiating these. The Cockcroft Report in 1982 emphasised the importance of discussion in mathematics as a means of communicating mathematical ideas and, as Alexander (2004b) points out, whole-class situations do not lend themselves well to exploratory discussion. Collaborative group work would provide for such discussions, where personal understandings are constructed through social interaction, supporting Siegel & Borasi's (1994) vision of the 'inquiry classroom' (p.210) and Bruner's view of understanding 'fostered through discussion and collaboration' (Bruner 1996 p.57). Alexander's dialogic classroom where 'children talk to learn', and what pupils say 'probably matters more than what teachers say' (2004b p.26), also draws attention to the importance of developing pupils' understanding of mathematics through talk.

The recently published review of mathematics teaching led by Williams (2008) and OfSTED Report (2008) highlight the need to develop pupils' mathematical thinking, understanding and investigative problem-solving skills and my study raises important concerns regarding student teachers' preparedness and ability to undertake this, based on their current learning experiences.

Reflection

In reflecting on my study of students' evolving professional knowledge, I have become aware of the extent to which my knowledge and understanding of mathematics learning and teaching, and the process of research, has developed. My learning journey reflected stages of the conscious competence model, taking me at various times from unconscious incompetence to, in some respects, reflective competence.

At the outset of this research I believed I understood interactive whole-class teaching and how it could be implemented effectively in the classroom. In the course of researching and thinking about what interaction might mean for mathematics teaching and learning, my own 'incompetence' became evident as I realised the limits of my own understanding. In many ways I learnt alongside students as we explored aspects of interactive teaching. As Friere, explains, 'the teacher is no longer merely the-one-who-teaches, but one who is himself taught in dialogue with the students' (Rogers 1983 p.81). I also underestimated the demands that cognitively challenging aspects of interactive teaching in mathematics placed on novice teachers and learned a great deal about their progress through the stages of novice to expert teacher and the demands this placed upon them.

In a similar way, I believe I entered the research process with a deceptive sense of competence, based on previous successful small-scale projects I had undertaken. Many false starts, rewriting and reworking of data took my journey as researcher through several deskilling and demotivating stages, frequently convinced my research had little merit and was not worthy of completion. Dewey (1933) claimed reflection on an experience, rather than the experience itself, leads to learning and time spent questioning the process of this research, its purpose, focus and methods helped further my knowledge and understanding. Rogers (1961) suggests direct confrontation with practical, social, personal or research problems, facilitates experiential learning and these have all featured to some extent throughout my research process. Confronting family problems, stressful work demands and limited time, whilst also responding to the demands of research, involved much questioning and soul-searching. On many occasions, the research had to be put aside and at times I doubted my ability and motivation to continue. Rogers asserts that self-evaluation should determine progress or success in experiential learning; this often proved to be a painful process. The 'state of doubt, hesitation, perplexity, mental difficulty, in which thinking originates' (p.12) which Dewey (1933) associates with reflection, was only too often present as I revisited and revised my research, seeking ways to resolve the doubts and unravel the perplexities. Some of the issues and questions that arose are addressed in the sections that follow.

Evaluation of methods

The study was undertaken in two stages and entailed the collection, transcription and analysis of large amounts of data. This proved complex, time-consuming and problematic in collating effectively to create a cohesive story.

Field notes from observations and initial interviews plus digital recordings from interviews provided the majority of qualitative data, and several problems arose related to my collection and transcription of these. Initial digitally recorded interviews created a problem, as attempts to transfer them to the computer succeeded in deleting them from both sources. Extensive searching by technicians could not locate these in either format and I had to rely on supporting field notes.

On reflection, some of the semi-structured interviews may have provided data that were more elucidatory, had I probed students' responses further. For example, it would have been helpful to explore the students' use of questioning and their follow through of pupils' responses, particularly as this mirrored concerns regarding my own questioning. Maintaining a full written record of early group interviews also proved difficult. I initially rejected the idea of recording these discussions, due to the difficulty of identifying different voices and utterances during open discussions. Later, as individual voices became familiar and more easily identifiable, the problem lessened and I made digital recordings. Not having a broad range of extended research involvement prior to this study was clearly a contributory factor. Much has been learnt from the experience about effective questioning and ways to further probe participants' responses.

Initially I believed grounded theory, provided the basis for my analysis of data. As my understanding of this developed over the two years of the study, I came to see my approach more closely aligned with interpretive qualitative analysis that followed a process of 'noticing: making observations, collecting; writing field notes and tape recording interviews and thinking' (Seidel 1998 p.4).

Initial coding was by hand using highlighter pens and margin codes and, although time consuming, worked well for the first set of data involving 122 written responses. With further data from individual interviews, observations and focus group interviews, this became more difficult as analysis of each was needed before collection of subsequent data. This was not always possible hence analysis could not always be used to inform later data collection as intended. At this point the computer software NVivo was obtained and initial problems in installation, ensuring it ran consistently and familiarisation with the program, delayed analysis. Nevertheless, coding was simplified and all entries under specific codes could be accessed to give a clear overview when needed. At times I felt this atomistic approach caused me to lose sight of contextual information or the broader picture. There were occasions when I needed to return to the original transcripts as specific coding proved less helpful. For example, one code used initially was; 'discussing in pairs and groups', with the coded entry, 'talking to the children ... talking to each other as well – talk partners'. When checked in context, a comment followed which suggested this did not happen much in mathematics because, 'sometimes there's one answer and you want them to think of that one answer by themselves' (FG2.2.Carla 01/05). This put the statement into a different context than assumed from accessing the coded item. This questioned my skill in coding, which should analyse rather than label, although this improved over the study and were I to begin again, I believe my coding would be more accurate and apposite.

A further difficulty arose from initial participant referencing. Having decided on pseudonyms at the beginning, I frequently used initials or first names in interviews and field notes, changing these to pseudonyms at a later stage. As some of the students recorded were not from the sample twelve, I had a mixture of names, pseudonyms and initials that I could not reconcile with total accuracy, resulting in some data not being used to full effect. Additionally I identified data in a variety of ways, so could not establish consistently and unambiguously when, and from where, it was obtained. The large amount of varied data made it imperative clear structures were established from the start of the study and, from those early mistakes, I have learnt the importance of deciding how to identify the who, when, and what of data collection.

Video recordings of the students' teaching proved effective in aiding recall, as many participants could not remember actions and verbal interactions that appeared on the video. Had I relied on students' recall a different picture may have emerged. Video recordings also aided students' reflections, as assumptions they held of actions and questions they used, were challenged on replay, prompting further questioning. The recordings were also useful confirmation of my field notes and interview data and I could return to the recordings to check these where necessary. Students viewed the video immediately after their lesson, on reflection it may have been useful to allow more time for this, perhaps overnight. However, there were time constraints; students usually had only 20–30 minutes immediately after the session for discussion, and the risk of losing the immediacy of students' responses to their sessions. Overall, I believe students watching recordings immediately after their lesson, remains the better option.

Working closely with students throughout the year, as tutor and researcher, could have created tensions. Occasional difficulties did arise, particularly where students were struggling during school placements. Lessons that did not go well or negative feedback from mentors sometimes provoked emotional responses. On these occasions the research agenda was postponed, whilst I adopted a tutor role, providing support and guidance. Similarly some students occasionally asked course or assignment related questions during interviews, or requested more specific feedback about the session observed. In these instances interviews were concluded and checked with the student, before I addressed tutor-related issues. This raises questions about the feasibility of maintaining a dual role of tutor and researcher, and occasionally, the necessity of curtailing the research agenda with individual participants when I believed the needs and entitlement of students took precedence over research.

Strengths and Limitations of the Study

A case study, set within one ITE provider and several partnership schools, can only provide a snapshot of current practice, but I believe is sufficient for others with similar interests to compare with their situations and thus has relatability (Bassey 1981). Following a small group of students through a one-year course and their first year of teaching could be considered a strength of the study. It allows for consideration of changes in students' views and practice over time and influences on these, based on students' own perceptions. Nevertheless, I am aware this group, and the schools involved, are not representative of all PGCE students and partnership schools and thus cannot provide a generalised view.

Implications for future research

A small-scale study, addressing several aspects of mathematics teaching and learning, can present detailed information highlighting issues of concern in mathematics education. The pedagogy underlying interactive whole-class teaching in mathematics continues to need further study. Further knowledge of the impact of this approach on children's mathematics knowledge and understanding would be of value, alongside an examination of the mathematics currently being taught and assessed through SATs, and the effects of such nationalised testing on pupils' mathematical thinking.

It became evident from my study that collaborative creative problem-solving, a key feature of interactive teaching considered to extend pupils' mathematical thinking, is not an established feature within most mathematics lessons. Hargreaves (2003) argues that we live in a knowledge society stimulated and driven by creativity and ingenuity, and schools within this knowledge society need to create these qualities if their people and nations are not to be left behind. Yet, he claims that:

> instead of fostering creativity and ingenuity, more and more school systems have become obsessed with imposing and micro managing curriculum uniformity...schools and teachers have been squeezed into the tunnel vision of test scores, achievement targets and league tables of accountability (p.xvii).

This echoes concerns expressed in Chapter One related to the recurrent cycle of reform in mathematics education. The development of creative thinking, creative curricula and collaborative problem-solving within mathematics are areas that demand further consideration and research.

Certainly the use of talk in the classroom is an area of continued interest. Alexander has noted 'growing recognition that dialogic forms of pedagogy are potent tools for securing student engagement, learning and understanding' (Alexander 2006 p.3) and has suggested the term 'dialogic teaching' 'replaces both the vagueness of 'interactive' and the organizational restrictiveness of 'whole class teaching' (2004b p.23). I believe ITE, schools and teachers' professional development programmes would benefit from prioritising development of effective questioning and discussion to support and extend pupils' mathematical understanding and thinking.

The changing role of higher education in initial teacher education, and focus on furthering partnerships with schools, is another area worthy of investigation. The current development of Professional Development Schools, funded and supported by the TDA, involves schools more fully in training teachers in school across a range of professional issues. This initiative provides opportunities for a more collaborative approach between schools and HEIs, that could focus on developing scaffolded learning, reflection and metacognition for both mentors and student teachers. In order to achieve consistency in students' experience and development, HEIs and school mentors would benefit from opportunities to:

- create shared understanding of students' developmental stages, and the impact of these on their practice in the classroom
- establish effective mentor support that scaffolds students' learning and development
- explore and develop a shared understanding of effective teaching and learning in mathematics.

Dissemination of Findings

The findings from this study may be of interest in several forums and plans have been made to present a summary within my university research forum and to the School of Education Partnership Development Committee.

Conference papers and journal articles may also arise from key aspects of the study and further research is expected to develop from the ideas outlined above, for example the design and evaluation of a mathematics specific mentor development programme. The design and data-collection methods adopted in my research study, in particular my use of focus group discussion and video-stimulated recall of observed teaching, and the rich data enabled through these are also, I believe, worthy of further evaluation and discussion. My intention is to undertake a fuller evaluation and share this through my university research forum and through publication in relevant peer-reviewed journals. Through further research and development I will thus continue to contribute to current education and mathematics education research.

Conclusion

The education of future teachers and their ability to create and develop mathematically confident, creative and competent pupils will always be of concern to those in education. We owe it to future generations to provide high quality teaching and learning opportunities that will inspire and challenge pupils.

From this study I offer a way of looking at the learning journey of student teachers, highlighting several issues related to interpretation and implementation of interactive teaching in mathematics. I suggest teachers' and students' knowledge and understanding of the pedagogical principles underlying interactive teaching need to be developed further to foster pupils' creativity, higher-order thinking and collaborative problem-solving. Learners need time to, reflect, pursue lines of enquiry that stimulate, puzzle and excite them and communicate their thinking to others if they are to develop as mathematical thinkers and innovators. As the recent Williams review (2008) and OfSTED report (2008) indicate, current mathematics teaching does not enable this. Taking account of the demands of future society, I suggest these skills are essential for the next generation and as

Beare (2001) and Alexander (2003) maintain, positive change is essential in moving mathematics education into the 21st Century.

Such change would involve, for example, mathematics educators ensuring ITE students become creative, innovative teachers, and develop subject and pedagogical knowledge that will enable them to stimulate and enthuse pupils, develop their higher order thinking and engage them in collaborative creative problem-solving, and also to take a critical stance in considering new initiatives. Similarly, for schools to ensure professional development opportunities that enable teachers and mentors to work with HEIs towards a shared understanding of initial teacher development, and mathematics teaching and learning. Furthermore, a creative and dynamic review of statutory assessment in mathematics is required to release teachers and students from the narrow confines of current SAT demands that reduce mathematics teaching to test preparation and the learning of rules and procedures. Instead, opportunities are needed for pupils to demonstrate their application of mathematics through creative, collaborative problem-solving. It is perhaps time for repeated demands over the past century to be addressed if we are to ensure our young people develop as mathematical thinkers and innovators, equipped to meet the demands of the next century.

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APPENDICES

Rank the following in order according to which you think are the most important aspects of maths for children to learn.

number 1 - 10

- ☐ **Measurement**
- ☐ **Algebra and number patterns**
- ☐ **Solving number problems**
- ☐ **Mental calculations**
- ☐ **Correct written procedures for calculations**
- ☐ **Data handling/graphs**
- ☐ **Number operations (inc. fractions/decimals etc)**
- ☐ **Shape and space**
- ☐ **Tables and number facts**
- ☐ **Investigative approaches**

Give reasons for your choice of first and second:

....

DECLARATION

Could you indicate below whether you would be willing for your responses to be used as data for on-going research on direct interactive whole-class teaching in mathematics. Please note that names will not be used and identity will remain confidential. I would be very grateful for your help,

many thanks, Jean

I am/am not willing for my responses to be used for the above research purposes.

I am/am not willing to take part in further interviews/discussions following these responses

Signed .... Date ....

School of Education

15th Sept.'04

Dear

Thank you for completing the initial questionnaire about your experiences of mathematics in school which will provide some valuable data for the research project with which I am currently engaged.

You kindly indicated your willingness to be part of later interviews related to this questionnaire and I am writing to ask you if you are still happy to undertake this. The interview will take the form of a small group discussion with other members of the PGCE group. expanding on some of the questions in the original questionnaire. this will last for 30minutes.

The discussion will be tape-recorded and the data stored on computer with transcripts taken as and when required. Data presented in the research will be anonymous and any reported comments or conversations from individuals will be checked with them before submission. to ensure that they are reported or interpreted accurately.

Following the discussions I may ask to observe you teaching a maths session whilst you are on school experience and hope that you will be willing to take part in this also.

If. at any time you decide to withdraw from any of this research- based activity then all data related specifically to you will be destroyed.

If you are willing to continue to contribute to this research please confirm by signing the agreement below.

With thanks for your help.

Jean

I have read the above and am happy to take part in the discussion groups and be observed teaching maths whilst on school experience.

Signed: .... Date: ....

[redacted]

8th Nov. 2004

Dear

----------, who is undertaking her first school experience with you, has been part of a doctoral research study that I am engaged with, which is looking at student teachers' interpretation and implementation of direct interactive whole class teaching in mathematics.

The study so far has involved students in questionnaires and interviews, alongside course based activities. Plans for the next phase of the research include observations of the students teaching part of a mathematics lesson. The intention is to observe the student teaching, and use this as a basis for discussion with the student, following the lesson.

I am writing to ask if it would be possible for me to visit -------- and observe her teaching a maths lesson, following this with a short discussion with her about the lesson. All information gained will be confidential and used solely for research purposes. The school and pupils will not be identified in the report but your support for the research will be acknowledged anonymously in the final submission.

If this is acceptable to you I can be contacted by email: [redacted] or you could let ------know. I will then get in touch with --------- to arrange a time for the visit that fits with her timetable and is convenient for both her and the school.

Thank you very much for your help and support for this research project.

Jean Ashfield
Director of Primary PGCE Programmes

20th May 2005

Dear

---------, who is currently undertaking his final school experience with you, has been part of a doctoral research study that I have been engaged with over the past year which is looking at student teachers interpretation and implementation of direct interactive whole class teaching in mathematics.

The study so far has involved students in questionnaires and interviews, alongside course based activities. Plans for the next phase of the research include observations of the students teaching part of a mathematics lesson. The intention is to video the student teaching, and use this as a basis for discussion with the student, following the lesson.

I am writing to ask if it would be possible for me to visit -------- and observe/video him teaching a maths lesson, following this with a short discussion with him about the lesson. All information gained will be confidential and used solely for research purposes. The school and pupils will not be identified in the report but your support for the research will be acknowledged anonymously in the final submission.

If this is acceptable to you I can be contacted by email: .... or you could let ------know. I will then get in touch with --------- to arrange a time for the visit that fits with his timetable and is convenient for both him and the school.

Thank you very much for your help and support for this research project.

Jean Ashfield
Director of Primary PGCE Programmes

Profiles of Participants

Carla (age 31-40)

Carla found mathematics difficult and confusing as a pupil, although she had liked it for one year in secondary school when she had a 'cool and funky' teacher. She felt insecure and lacking in confidence at the beginning of the course. She remembered little from her mathematics lessons but knew that she 'survived by learning the rules', knowing how to get the right answer but with little understanding. Carla hoped to include a lot of practical work in her lessons but added that she wasn't sure this was necessary for all pupils.

Freddie (age 41-50)

Freddie was confident in his mathematics ability and felt he had a natural aptitude. He found mathematics fun at school, mainly because he found it easy and liked the way it was taught. He described his lessons as 'teacher at the front explaining methodology using blackboard and chalk', followed by the class working silently on exercises in their books. Times-tables were learnt 'parrot-fashion' and regularly tested and Freddie felt it was crucial to teach these basics and the 'building-blocks' of mathematics.

Harry (age 31-40)

Harry felt confident in mathematics, he had enjoyed it at school, finding it interesting and satisfying and as he reported, was 'brought up in a maths environment'. He recalled lessons based solely on textbooks which he worked through in sequence with help from the teacher if he had a problem. Looking back he feels he was 'cheated out of a learning experience' with this reliance on textbooks and hoped he would provide more engaging experiences for his pupils through 'interactions and hands-on experiences'

Hiby (age 21-30)

Hiby recalled mathematics being interesting and quite satisfying. Lessons started with a 'taught' part followed by exercises from books. She remembered having some good teachers who were encouraging and some practical work with shapes, making symmetrical tiles etc. Hiby felt she was more creative and artistic and therefore enjoyed the visual elements of mathematics. She expressed a wish to include that aspect more in her own teaching but also to approach mathematics through 'clear step-by-step instruction'.

Jared (age 21-30)

Jared hated mathematics as a pupil, he found it difficult to understand and was dreading having to face it again as a student. He remembered his lessons beginning with the teacher working through examples and the class then having a set of questions to work through. At the end of the week they were tested and those who got less than 15/20 had to repeat the test. He disliked his teacher and remembered having his hand smacked with a ruler when he got times-tables questions wrong. In secondary school he remembered occasional 'projects' in mathematics which he quite enjoyed as there was less pressure to get 'right answers'.

Lise (age 31-40)

Lise found mathematics boring at school and difficult to understand, leaving her lacking in confidence and anxious about doing mathematics again as a student. She recalled lessons which involved the teacher at the front going through examples on the board, but often absented herself from lessons as she 'hated maths and couldn't understand anything'. Lise was keen to make mathematics fun, using games, role-play and lots of practical work.

Mags (age 41-50)

Mags struggled with mathematics at school, finding it very confusing but she was enthusiastic about learning more as a student. She recalled teachers being quite disciplined, explaining a particular aspect and pupils then working quietly from textbooks, which she 'instinctively liked' because she liked the 'idea of control'. Mistakes and misunderstandings, she recalled, were mainly picked up from homework. Mags wanted to ensure that her pupils had a sound foundation through good teaching which she considered 'requires constant repetition'.

Nell (age 21-30)

Nell struggled with mathematics, finding it very scary and was very worried about facing it once again. Her memories were of very didactic lessons with methods explained and then the class working on sets of exercises. The teacher wasn't very flexible and couldn't explain in a different way if she didn't understand so Nell relied on her friends. As a teacher Nell wanted to be able to simplify things and think of different ways to explain concepts.

Rhea (age 21-30)

Rhea found mathematics interesting and quite satisfying as a pupil but was concerned about doing it once again. She remembered her teacher loved mathematics and understood a lot but 'although good in some ways the class couldn't follow him and became bored'. Lessons started with examples on the board and the class then completed exercises while the teacher sat and marked other work. If pupils struggled they went to the desk and the teacher explained it again. Rhea was keen to 'introduce an element of fun and interest' in her mathematics teaching.

Saba (age 21-30)

Saba struggled with mathematics as a pupil and was concerned about doing it again as she lacked confidence in her knowledge. Her memories of mathematics lessons were an introduction to the topic with examples completed on the board and then the class worked from workbooks. If she made any mistakes or misunderstood the teacher would go over the example again and she'd try again to get the answer right. Saba liked to be able to work in groups and to use apparatus as this helped her to understand mathematics better and made it more fun. She would want to use this approach herself, breaking down topics 'so they are easier to digest'.

Simon (age 21-30)

Simon hated mathematics at school, finding it boring and difficult. He recalled very dry, didactic lessons with lots of rote learning of tables and rules that he had to remember. Generally lessons involved pupils working from textbooks on their own with very little interaction with the teacher. Paul was keen to make maths fun and interesting and didn't want his pupils to be afraid of getting things wrong or asking for help.

Paul (age 31-40)

Paul found mathematics quite dry and boring. He recalled lessons with examples demonstrated on the board followed by individual work from textbooks. The teacher was not very approachable or helpful if pupils were struggling and everything was very formal and hurried. However his father would go through the work with him at home, which helped him to understand rather than just know facts. Paul's aim was to make mathematics interesting and enjoyable for pupils.

Interview Questions

6.1

Post Questionnaire Follow–up Interviews (Oct 2004) own experiences of maths

Stimulus Questions

R: Tell me a little more about your feelings about maths

R: What was a typical structure of a lesson that you had then?

R: What do you think your approach to teaching maths is going to be?

R: What are the key elements of good maths teaching do you think?

First School Experience Interviews Nov /Dec 2004 (FSInt)

Observed Lesson: Stimulus questions

R: Tell me about the lesson, in what way was it interactive do you think?

R: What about questioning, what kind of questioning did you use?

R: Is there anything else you might have included that you consider to be interactive?

R: Was there any reason why you didn't include this?

Post First School Experience Interviews Dec 2004/Jan 2005 (FSInt)

Stimulus Questions

R: So thinking back, you filled in the questionnaire about your own experiences of maths. How much of what you observed was similar or different to your own experiences?

R: What about your own teaching were you able to actually put into practice interactive teaching - some of what we have done in the sessions.

R: Are there aspects of your teaching that you think you'd like to develop further?

R: What do you think has influenced your teaching approach?

PGCE Post First School Experience: Session discussion (14 .1.05)

Q1 Lessons/teaching which inspired you or your own teaching?

Q2 Lessons/teaching which you might question?

Q3 Do you think the ideas you had about how you would teach maths have changed since you started the course?

What has changed?

Q4 What has influenced your learning most?

6.2

Final School Experience 06/05 (FPInt)

Stimulus questions

R: So talk me through the interactive part of what you were doing. Tell me what your aims were.

R: What questioning, the kinds of questions you asked. Had you thought about it in advance?

R: In terms of interactive teaching is there anything that you would want to develop further

R: How similar is the way that you're now teaching to the way that you were taught in school or how different is it?

6.3

Newly Qualified Teachers – observed lesson Nov. 2006

Stimulus questions

R: Tell me about the way you teach maths now, what's important to you about how you teach?

R: So is it... is how you teach now different from say how you were doing it on school experience? Can you remember that?

R: So what do you think has influenced the way you teach maths most?

R: Is there any aspect of your teaching that you think yeah I still would like to develop that more

R: As you know what I'm looking at overall is what is known as interactive teaching – how would you describe it now having worked for this last year
R: Looking back particularly to your time in university what's the one key thing you think you took away from the maths sessions what's the one thing you remember?

FSInt Jared 12/05 *Appendix 7*

R: : So in that short questionnaire you did at the beginning you reflected on your experiences of teaching and we talked about that, what I am curious about now is how what you observed in school, how it compared with your own experiences ...how different and how much the same was it?

J: Well ...I don't really remember to be honest, the only stuff I remember about is it was much more book based – it was just carry on from the day before – no learning objectives, starters or plenaries... we did do investigations sometimes and projects in pairs. I wasn't good at maths though and don't have much confidence myself
① text b
② investigat.
③ lack confiden (knowledg

R: You visited a secondary school last week how did that compare to what your experiences were – was that very similar?

J: Yeah, that was very similar, although I didn't go into a maths class for long ... but I thought that it would be learning objectives, more interesting activities and what have you but it was more working from books which I was used to.

R: What about your own teaching?

J: The starter was the part of the lesson where you kind of ... that was most interactive, with quizzes, bingo and the whiteboards, and then **the middle part there was some. Rather than questioning I tended to bring children to the front to do things – I was worried I suppose about how to ... well** their behaviour, sort of keeping them quiet – **that was difficult when they all called out and I thought I can't do this and they don't do it with V.. *(classteacher)* so she must think I'm not much good at this so ...** it's a bit scaring – so – **at the time** I wasn't that confident to ask questions – if they went beyond what I knew you know I'd panic **... I was more as time went on... I got more used to asking open questions... a lot of that was from my own experience.. I was very aware ... I was trying to include children who were often ... Well they just didn't.. they weren't really taking any notice or any real part ...I suppose I was just more conscious of them rather than the others**
② practic
③ to the fr managem behav
③ confiden knowled
- self focus survival
④ pupil concerns

R: What about when they were then working...?

J: Then .. I was kind of more just wandering ... there was never a moment when nobody had a question or somebody wanted help - there I suppose, I was after a while anyway, .. in the last sort of two weeks of it ... it was more one to one and I was asking much more the right kind of questions – although I asked the right questions I didn't really give the right responses to get them to think more ... just an answer really as I still didn't know enough to know what to ask. There was all the plan to get through too, **I knew what V... wanted done and there** wouldn't be time tomorrow as we'd have to move on so ...
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③ knowledg
③ time rest
④ self beginning to move to pupil

R: What if you thought they didn't really understand?

J: Well that's hard because there's not the time to go back over so – **yeah, there were some, I think maybe I just went through the questions, a bit at a time telling them how to do each bit so they got to the answer and could then do the others – but maybe they still didn't understand – I could have done it differently if I knew more or how but ...**
③ time
② telling to getting to answer
④ self

R: So, are there aspects of your teaching that you think you'd like to develop further?

J: A lot of it was just being kind of aware of... if the way I was approaching was right .. **that was sort of less just moving them on .. that was even when I had C (fellow student) who was good at maths and helped me with ideas and planning.**

R: Is there anything you've thought .. I'd really like to develop that ...

J: The whole ...I mean now that I've done the assignment this whole idea of higher order and open questions ... although I was aware of the fact that we should be using them I used ... and because of inexperience it was taking too much time ... **we just sort of got bogged down in stuff... on my lesson plans I had** ten **questions to get through... I mean I think because** I wasn't very confident with maths **I spent more time preparing and it turned out** the maths was the subject.. because I **thought about it so much ..I was best at ... *(because you prepared so well)* exactly! ... I just fall down on paper -** I was kind of preparing all my questions **and I actually remember thinking I needed to write up questions and stuff I was doing them for my diary and I'm embarrassed and a bit conscious of the fact that other teachers seemed to be making them up as they went along but I couldn't** as I didn't know enough.

R: What do you think has influenced your approach to teaching?

J: I think from the course **really and** watching other teachers **...I hadn't really ...** I didn't know anything about teaching maths **whereas the other subjects I knew more about..** perhaps **if I hadn't been on this course I would have just walked into a school** and taught **like that ...** like I was taught. **At the time anyway** I lacked any confidence - **I always** associate maths with fear **I was worried about it even at the start I just remember when I** went to do the maths test **and then when we started ... sitting in maths lessons being really scared and worried. I'm now very relaxed and see it as fun whereas I always thought of it as serious.**

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(3) lack confide
(3) fear

Interactive features – Observation Record

<table>
<tr><th>Active Involvement (Practical Activities)</th><th>Questioning</th></tr>
<tr><td></td><td rowspan="5"></td></tr>
<tr><th>Discussion</th></tr>
<tr><td></td></tr>
<tr><th>Creative Problem Solving (Investigative)</th></tr>
<tr><td></td></tr>
</table>

Jared 2/12/04
Year 4 'Class' Maths
Topic 'Romans'

Interactive features – Observation Record

<table>
<tr><th>Active Involvement (Practical Activities)</th><th>Questioning</th></tr>
<tr><td>O/M Mini-whiteboards - Bingo using multiples of 10</td><td rowspan="5">O/M Recap on multiples → 'What are 4 tens?' '2 tens?' '5 lots of 10?' (Incorrect answer 25) moved to another for correct response.
Bingo - series of these 'closed' questions for recall. Several general management questions e.g. 'Do you all have your numbers now?'
______
Main : Worksheets - worded no. probs
P I don't get this
J. What are you trying to find out? (open potentially)
P. About the boots
J. How much does a pair of boots cost? (closed)
P. 8
J. ... and how many pairs of boots are there?
P. 10 pairs
J. So what is 10 lots of 8? [no further probing]
P. err... 80?
J. That's it - that's all you have to do
______
J How much is a helmet?
P. 6 denarii
J. How many are there?
P. 10
J. So what is 10 lots of 6?
P. 60?
J. OK - carry on like that
All t/p interactions were closed questions or management questions
______
Plenary.
Examples from sheets - question asked - correct answer given - all 'closed' low demand.</td></tr>
<tr><th>Discussion</th></tr>
<tr><td>None planned
T/P all question/response/feedback or 'funnelling'
P/P informal - sharing answers already worked out, no working out together or discussing strategies.</td></tr>
<tr><th>Creative Problem Solving (Investigative)</th></tr>
<tr><td>Worded number problems based on multiples of 10</td></tr>
</table>

O/M → Oral and Mental Starter
T/P Teacher/Pupil
P/P pupil/pupil

Focus Group Discussion (FG2.1)

re. own experiences of maths

R: *OK, so, would somebody like to start with their feelings – what their feelings are about maths?*

Simon: I can start with my secondary experience which is much more clear in my memory than my primary maths teaching that I had .. erm .. it was very erm.. it was a very negative view point I'm going to offer because – mainly because of the teacher that we had, er … his style of teaching was very much directed solely at the whole class and there was very little .. if any kind of group work or interaction between the students. Erm .. the main problem was the behaviour of the class which was running riot and the teacher we had erm . Mr Massey, a very nice man, but he had a very tough time, I don't think, erm he couldn't really .. well he couldn't really control the class so it was him at the board talking outwardly and nobody was taking anything in. I was a quiet member of the class relatively .. I wasn't naughty, so .. but, I can honestly say I don't think I learnt or remembered anything from my whole time there and the only way I actually got through my maths GCSE O Level at the time was through a maths tutor – one–to-one … only for like 3 or 4 months but in that time it was fine but erm the teaching was not the best .. sadly so erm ..

R: *So how did you feel about maths at the end of it?*

Simon: Clueless

R: *Clueless?*

Simon: Clueless I didn't have a clue what was going on .. at all … erm no confidence in it erm … yeah

Jared: Yeah, I think the confidence thing is really important because I never had any confidence in maths at all and it really ..affected how I performed in class and how I perceived my ability to get on with the subject really.

R: *Did you like maths?*

Jared: No, I hated it, erm … I .. it was always my weakest subject and all my friends were in the top maths group in secondary school and I wasn't and it was .. it was a big deal for me and erm.. I had a lot of pressure from my parents to pass my GCSE and I did luckily because my maths teacher took a few of us on at lunchtimes to try and get us up to standard, but erm .. my dad and I .. this is true.. burnt all my maths books when I passed .. when I got my results, because my dad failed his maths 'O' Level about three or four times and so he'd always hated maths as well.

R: *What er.. what approach, what was a typical structure of a lesson that you had then?*
Jared: Erm.. I .. in primary school I can't remember a huge amount but I don't remember ever seeing the point of what we were doing, nothing .. it was never applied to real life situations in primary school it was all kind of copying things down from the board and working through books at our own pace. Erm .. in secondary school the teachers sort of, they… they … some teachers tried to make it relevant –all the kind of swimming pool questions for volume and things like that which was more interesting and I enjoyed, but I didn't ever really understand the point of, you know, how maths was going to be useful to my life.

Rhea: I can't remember maths, I can't remember anything from primary school apart from the maths lessons because they just petrified me because we had like one standard lesson like for the

SESSION PLAN

Subject/Theme Maths	Year Group 6	No in group/class 22	Date 4/12/04

Specific learning difficulties and disabilities	Resources
	Blackboard, powerpoint pres.

FS/NC/PNS Ref:	Previous learning/experience to be built upon:
MA3 Construct a line graph	Charts, median, mode, range and mean

Learning Objectives	Activities (inc. differentiation and use of ICT, key vocab, questions)	Assessment
To be able to construct and interpret information in a line graph	Intro (10 mins) Greet year 6 Explain that you are going to start off with a quick recap on bar charts Go through powerpoint presentation on bar graphs; ask pupils – what are the four main features on a bar chart? What do we do if we are comparing two sets of data i.e. favourite colours for boys and girls? (find the difference/subtract) Main activity (20 mins) Get pupils to take a sheet and passit on, get two pupils to hand out books Tell them we're going to look at line graphs Go through powerpoint presentation on line graphs Get them to come up to help draw chart on board Read through questions on sheet Write data for temperature on board – get them to draw up their own table and line graph Go round and observe pupils' work Draw up a graph for them to fill in for the plenary	What: Can they organize data into a table and construct their own line graph? How: Written work Who:

First School Experience – Observation

PM1 8.12.04 Harry

Context
Year 4 mixed ability class in a Surrey Junior School. Activity observed was an investigative/problem solving task – Frogs.
Pupils all had coloured counters and were working in pairs. Initial introduction was a whole class explanation and demonstration of the task using 6 pupils at the front sitting on chairs.

Student Teacher: Now what we have are 6 frogs – 3 on this side and 3 on this side and an empty chair in the middle. The frogs have got to change places so that these 3 are on that side *(uses hands to indicate*) and these on that side. The rules are that they have to move one at a time and can only move in one direction – these move this way *(points)* and these that way – they can't go backwards. They can either move into an empty space in front of them or jump over one frog into an empty space. Do you all understand? Any questions?
Pupil 1: How do we know which way they're going if they're facing this way?
ST: Ah, let's have boys on one side and girls on the other to make it easier. *(changes the groups around).* The boys go this way and the girls that way OK?

ST: Right, which one shall we move first? *(several pupils put their hands up)* Let's have few more hands *(a few more go up)* OK J what do you think?
P2: T *(boy)* could move to the space
ST: OK T can you move *(T moves into empty chair)* OK, Now who shall we move? *(a few hands go up, some chatting around the room and a few not watching)* OK M who shall we move where?
P3: J (boy) next to T
ST: OK J you move next to T. What's the next move then? *(lots of calling out with a few hands up, ST responds to the called out suggestions)*
ST: So you think K (boy) moves next to J? *(lots of calling out agreeing or disagreeing ST ignores this and continues)* Right K you move next to J
ST: Now who can move next? *(a few hands go up and lots of calling out)* OK S what comes next?
P4: J has to jump over K
ST: But that means he will go back and he can't do that. *(Lots of chatting and calling out)* So what move can we make?
P2: No one can move then.
ST: You're right, the only space is there *(points)* and J or K can't go back. Let's start again. *(moves pupils back to starting places, many of the class meanwhile are playing with their counters and chatting)*
ST: OK quiet now, I can't start until everyone stops talking. *(some are quiet but still some talking when he starts again)* who shall we move first?
P2: N
ST: OK N move into the space. Now who?
P5: L can move ..
P6: *(calls out)* or A can jump over L!
ST: OK let's go with that – A move in between L and N
P2: But that's the same now except its girls that's moved – it won't work! *(few really paying attention now, lots of chat and playing with counters).*
ST: Right, quiet everyone, there's far too much noise so let's move on. *(sends pupils at front to sit down)* Now you all have counters so I want you to try it yourself in pairs. You need 3 counters on each side and remember the rules *(repeats these amongst more chat)* OK off you go.

Student teacher moves around the pairs suggesting some use one colour one side and a different colour the other. Most are randomly moving counters but losing track of what they have moved where so start again.

ST: *(to one pairP6 and P7)* OK so what move can you make next? *(pupil responds with suggestion)* yes, you could but that won't work will it because then you can't move this one. Can you move a different one? *(pupil suggests jumping another colour over)* Yes that's better, see if you can continue *(moves away - they won't be able to because the next move puts two of the same colour together and prevents any further moves.)*
P7: That doesn't work either, I don't think you can do it, it's stupid *Scoops all the counters up and begins to put them in a pile of alternate colours)*
ST: OK everyone, let me have your attention, look this way. *(most are quiet and pay attention)* Some of you are getting muddled with your moves so you need to keep a note of what you have moved where. One way to do this is to draw your starting positions*(draws circles for the counters leaving a space in the middle)* then draw each move as you make it, then you can see where you are going wrong.
P6: But it doesn't work – you always get stuck.
ST: Has anyone managed it yet?
P8: We did once – but we can't remember how!
ST: well try it again and write down the moves then you won't forget. Right, you've got 10 minutes to see if you can do it.

ST sits with one pair and shows them how it works:
ST: OK which shall we move first? *(pupil moves one counter)* good, ok what next? *(pupil goes to move another of the same colour)* No we don't want to move that one – that's what we did up at the front and it didn't work so move the other one.
P9: But which one can we move then?
ST: you can move this one *(points to the other colour)*
P10: How?
ST: It can jump over that one.
P10: Oh, OK then, *(moves counter)*
ST: Now which one?
P9: I can move that one up now.
ST: You could but it will get you stuck next move because when you jump the next over you'll have two the same colour together and you want to avoid that, so move this one instead *(points) (continues in this way until they complete it)*
P10: We've done it! We've done it!
ST: OK we need to finish now. Did anyone else manage it? *(3 pairs put their hands up)* Well done, right you can all try it at home and see if you can get it.

SCHOOL OF EDUCATION

PRIMARY PGCE COURSE

MATHEMATICS QP3150

COURSE PROGRAMME

2004 - 2005

PGCE Mathematics Course Objectives

To enable trainees to

- Acquire appropriate subject knowledge and subject knowledge for teaching, with a particular focus on the design and management of learning in the primary classroom
- Develop their understanding of learning and teaching in the primary classroom with a particular focus on the teaching of numeracy and the wider mathematics curriculum
- Understand the importance of planning and assessment in the teaching of mathematics and be aware of a range of planning approaches and assessment methods
- Understand the role of the teacher in developing children's mathematical understanding
- Develop a critical understanding of the nature of mathematics and of how pupils learn and understand the subject
- Become conversant with the range of statutory guidelines and government legislation for education in relation to mathematics
- Become familiar with the National Numeracy Strategy and its implications for the teaching of mathematics
- Develop a reflective and critical appreciation of the complex factors involved in the generation of quality pupil learning experiences
- Fully develop the role and skills of a teacher of primary mathematics
- Achieve standards that contribute to the award of QTS,
- Develop enthusiasm for mathematics and enjoyment in the teaching of this subject within the primary classroom.

Curriculum Maths - Indicative Outline of Sessions

Introductory Activity:

- a short practical activity related to teaching and own competence eg mental strategies, a table square or short investigation.

Main Part:

- outline of objectives of session, their link to the ITT NC and required reading
- practical activity/lecture/group discussion etc
- feedback - individual and group presentation etc.

Review:

- informal assignment/discussion of session, current issues, concerns, etc.

Teaching Experience:

Many of the mathematics sessions relate specifically to school experience, however, if you have any particular concerns about maths related planning , teaching etc. before the start of school experience do arrange a meeting with your tutor who will be pleased to help

As part of each session, some or all of the following generic issues will be addressed in relation to the mathematical topic covered:

- Planning
- Assessment
- The National Curriculum
- The National Numeracy Strategy
- Development of language and mathematical vocabulary
- Children's errors and misconceptions
- Opportunities for ICT
- Links to the Pedagogic and Professional Studies programme

PAGE NUMBERING AS ORIGINAL

Mathematics Programme PGCE 2004/2005

Autumn Term 2004

Session	Wk. No.	Date Wk Beg.	Session Title
1	7	13.9.04	National Curriculum, Foundation Stage, National Numeracy Strategy.
2	8	20.9.04	Learning theory. Development of Early Number Concepts. Audit.
3	9	27.09.04	Mental Strategies, Standard/non-standard Algorithms Interactive Whole Class Teaching, Discussion and Questioning
4	10	4.10.04	Number: Place Value, Decimals, Zero. Planning a maths session
5	11	11.10.04	Calculations: Number Operations and Relationships;
	12	18.10.04	**Performing Arts Week**
	13	Week 25.10.04	**Reading Week**
SCHOOL EXPERIENCE 1 1st Nov – 10th Dec. 2004			

Spring Term 2005

6	**24**	**10.01.05**	Fractions and Percentages: Using and Applying Maths. Investigative Approaches; Problem Solving;
	25	**17.01.05**	**Broader Curriculum Week**
7	**26**	**24.01.05**	Data Handling (whole cohort)
8	**27**	**31.01.05**	Shape and Space; Transformational Geometry
9	**28**	**7.02.05**	Algebra and Pattern in Number
		Week 14.02.05	**Reading Week**
10	**30**	**21.02.05**	Measure, Angles. LOGO. (whole cohort)
11	**31**	**28.02.05**	Assessment: Use of Level Descriptions Inclusion: EAL; SEN; able and gifted; multicultural aspects; gender issues.
12	**32**	**7.03.05**	Creative Use of Maths Schemes; Cross-curricular Maths; Maths Trails
SCHOOL EXPERIENCE 2 **14th – 18th March '05**			
EASTER BREAK			

Summer Term 2005

FINAL SCHOOL EXPERIENCE
Prep Week 4th -8th April

11th April – 24th June 2005

PGCE Primary Mathematics Education Indicative Lecture Programme 2004/2005

Prior to each session you are expected to read the texts listed in the programme and are advised to read more widely around the topics. Williams and Shuard is recommended for more in depth exploration of some topics.

Each session links closely with the National Curriculum Attainment Targets and with the National Numeracy Strategy's five strands: Numbers and the Number System; Calculations; Solving Problems; Measures, Shape and Space and Handling Data and the links between these.

Reading References are given in the booklist below, but it is suggested that all trainees also read the appropriate sections of Williams and Shuard. The readings should be completed prior to the taught session or workshop.

Booklist 2004/2005

Required Reading

Askew, M.	Teaching Primary Mathematics London, Hodder and Stoughton 1998
Frobisher, L.	Learning to Teach Number Cheltenham, Stanley Thornes, 1999
Hopkins, C. et. al.	Mathematics in the Primary School. London, Fulton, 1996.
Liebeck, P.	How Children Learn Mathematics. Harmondsworth, Pelican, 1987.
Mooney, C et al	Primary Mathematics; Knowledge and Understanding Teaching Theory and Practice Learning Matters, 2002
Skemp, R.	Mathematics in the Primary School London, Routledge, 1989.

Recommended

Brissenden, T.	Talking About Mathematics. Oxford, Blackwell, 1988.
Duncan, A.	What Primary Teachers Should Know About Maths. Sevenoaks, Hodder & Stoughton, 1994.
Fox, B. et al	Using ICT in Primary Mathematics London, David Fulton 2000
Harries, T. & Spooner, M	Mental Mathematics for the Numeracy Hour London, David Fulton 2000
Headington, R.	Supporting Numeracy.

London, Fulton, 1997.

Hughes, M. Desforges, C. Mitchell, C.	Numeracy and Beyond Bukingham, OUP 2000
Merttens, R.	Teaching Primary Mathematics. London, Arnold, 1987.
Montague-Smith, A	Mathematics in Nursery Education, London, Fulton. 1997
Nickson, M.	Teaching and Learning Mathematics London, Cassell Education 2000
Straker, A.	Talking Points in Mathematics Cambridge, CUP, 1993.
Thompson, I	Teaching and Learning Early Number Buckingham OUP , 2000 (Ed)
Thyer, D. & Maggs, J.	Teaching Mathematics to Young Children. N C Edition, London, Holt, 1991.
Williams E. & Shuard, H.	Primary Mathematics Today Harlow, Longman, 1986.

<u>Useful</u>

Askew, M.	Recent Research in Mathematics Education 5-l6
Brown, T.	Co-ordinating Mathematics across the Primary School London, Falmer, 1997.
Burton, L.	Girls Into Maths Can Go. London, Holt, 1986.
Desforges, C.	Understanding the Mathematics Teacher,

& Cockbum, A.	London, Falmer, 1987.
Davis, P	The Mathematical Experience-
& Hersh, R.	Harmondsworth, Pelican, 1988.
Gardiner, A.	Discovering Mathematics -The Art of Investigation. Oxford, OUF, 1987.
Hughes, M.	Children and Number.
	Oxford, Blackwell, 1986.
Mason, J. et. al.	Thinking Mathematically.
	Wokingham, Addison-Wesley, 1987. "
Merttens, R. (Ed.)	Teaching Numeracy: Maths in the primary classroom
	London, Scholastic, 1996.
Paling, D.	Teaching Mathematics in Primary School. .
	Oxford, OUP, 1988.
Fine, S.	Investigations In Your Classroom.
	London, MacMillan, 1987.
Winteridge, D.	Primary Mathematics Co-ordinators.
	London, Chapman, 1989.

Journals (* are available in the KH library)

* Mathematics Teaching (UK)

*MicroMath (UK)

*Mathematics in School (UK)

Primary Maths and Science (UK)

Mathematics Teacher (USA)

*Mathematics Teaching in the Middle School (USA)

Teaching Children Mathematics (USA)

*Journal for Research in Mathematics Education (USA)

*For the Learning of Mathematics (Canada)

Some useful WWW sites:

http://www.standards.dfes.gov.uk/maths

http://www.qca.org.uk

http://acorn.educ.nottingham.ac.uk/Maths/welcome.html

http://www.enc.org

http://www.anglia.co.uk/education/maths

http://vtc.ngfl.gov.uk

Some useful addresses:

BEAM
Barnsbury Complex
Offord Road
London N1 1QH Tel: 020 7457 5535

QCA
Publications Hot Line: 020 8867 3333

The Association of Teachers of Mathematics
7 Shaftesbury Street
Derby DE23 8YB Tel: 01332 346599

The Mathematical Association
259 London Road
Leicester LE2 3BE

Initial Study

Summary

Initial Study

Data Analysis

In the initial study I collected data mainly through questionnaires and participant observation, My aim was to find out the students' attitudes to, and feelings and beliefs about mathematics, their prior experiences of mathematics teaching and learning as pupils themselves, and their developing knowledge and interpretation of interactive whole-class teaching. In order to obtain a broad overview of attitudes, beliefs and experiences I aimed to collect data from all 122 students, so generating a large amount of data for analysis. For this reason I considered questionnaires, providing mainly quantitative data to be the most appropriate method as they are a useful means of obtaining data from a relatively large number of people. Questionnaires are also efficient in terms of time and effort, and I was able to distribute both questionnaires to 122 students and have each completed and returned within thirty minutes. The completed responses are usually quicker to code and analyse that semi-structured or unstructured interviews and are a means of standardising the data collection process, in that all participants are asked exactly the same questions in the same sequence (Cohen et al 2000). Additionally, respondents may feel that they can be more open and honest if the questionnaire can be completed anonymously and this option was given to the students involved in my study.

Nevertheless, a good questionnaire with clear instructions and unambiguous questions can take time to create and it may not become evident that a carefully constructed questionnaire is not asking the right questions until data analysis is underway. In order to pre-empt this possibility I piloted the questionnaires with a small group of students from the previous year who found them unproblematic.

Students were asked to complete two questionnaires. The first, 'Approaches to Learning', questionnaire (Berry & Sharp 1999), was a structured questionnaire, which focused on students' approaches to and views of learning in general, indicating whether their ideas about learning tended towards the passive, teacher directed, didactic, absolutist view, or towards a more active, learner-centred, relativist perspective *(App.13.2)*. This consisted of twelve statements about learning and approaches to learning to which students indicated on a four-point scale, their strong agreement, agreement, disagreement or strong disagreement.

A structured questionnaire, with responses given as scaled ratings, was deemed to be the most appropriate for collecting this information from a large group (Cohen et al 2000), as analysis would enable patterns to be easily observed. However such questionnaires do not allow for added remarks, qualifications or explanations (Cohen et al 2000) which would perhaps ensure more accurate responses, although with large numbers of respondents such extra information would make analysis more difficult. To some extent the use of scaled responses does build in some degree of sensitivity and differentiation (Cohen et al 2000) and therefore addresses this concern at a manageable level.

The second questionnaire focused on students' views and initial feelings about mathematics, and their experiences of mathematics as pupils *(App.13.1)*. How students felt about mathematics was ascertained from their circling of two words out of twenty that expressed a range of feelings about mathematics. How they felt about the prospect of learning mathematics as part of their teacher education course was similarly addressed, with two words to be circled out of 16 words provided. This enabled responses to be aggregated to give frequencies. This type of question again has disadvantages, not least the variation in respondents' interpretation of the words presented, however the data to be collected from these questionnaires is only intended to provide a crude statistic (Cohen et al 2000), with further rich and detailed qualitative data being collected from a sample group at a later stage.

To ascertain students' views of the important aspects of mathematics for children to learn they were asked to rank ten aspects of mathematics in order of importance for pupils to learn and to comment on why they selected their first two. This approach enabled some degree of priority to be shown but ten items may have been more than students could easily address. There may also have been some aspects that respondents could not readily distinguish between and this approach forces them to make such a distinction. For these reasons the accuracy of the data must be questioned.

An open question was also included which required students to reflect on their experiences of learning mathematics as pupils. This required a more open-ended approach and respondents were asked to give a narrative account with four key points to consider in their reflection. This approach allowed for a more open and honest account and aimed to give the respondents a sense of ownership and responsibility for the data they were providing. It also provided a degree of rich qualitative data as an adjunct to the previous quantitative data. Responses to this type of question need to be analysed in a different way however as such responses do not lend themselves to any kind of aggregation, nor should they. The data obtained were analysed through a comparative coding method (Flick 2006) with each response read and key responses highlighted *(App)*. From this overall categories and themes were developed.

These four questions were presented as one questionnaire *(App.13.1)* and respondents were able to complete them within thirty minutes. This second questionnaire *(App.13.1)* was ordered with the simple non-threatening circling of two words first, followed by ranking aspects of mathematics, which was a little more demanding and required some possibly challenging decisions to be made, ending with the open ended-question which required more independent thought and reflection. It was hoped that this approach would build up confidence and motivation (Cohen et al 2000) It was also hoped that having a variety of forms of response on one questionnaire would keep respondents interested and focused, ensuring a greater completion rate, which seemed to be the case as all 122 were returned completed. The information collected provided helpful background data and informed more open and complex qualitative data gathering with a sample group (Punch 2005).

The questionnaires were followed up with individual and group interviews with the sample group of twelve students. As Miles and Huberman (1994) note, a group interview is an appropriate way of exploring questionnaire responses in more depth and I focused in particular on the open question, which asked participants for a narrative reflection of their own experiences as pupils learning mathematics. I kept field notes of the individual interviews and recorded and transcribed the group discussions. In both instances these were shared with the participants for corroboration. These were then coded sentence by sentence using highlighting pens and margin notes *(App.10)* The initial codes were then grouped together under broader categories and overall themes were compared with previous analyses and refined where appropriate.

In university sessions, as participant observer I observed students engaged in mathematical tasks and discussions that explored interactive teaching approaches and identified key features of this approach. Here data were provided through students' written responses to activities *(App.13.4)* and field notes completed after sessions and these were coded and compared to give key features of interactive teaching in mathematics. I shared these with the students and we refined them and agreed the four features used in the remainder of the study.

Summary of findings

Experiences, beliefs and attitudes

Students begin their Initial Teacher Education (ITE) courses already possessing implicit beliefs about teaching and learning and about their role as a teacher, based to a large extent on their own experiences as pupils, but also within families and wider society.

Findings from the Initial Study show that overall this cohort of students had experienced a traditional, knowledge-transmission approach to teaching and were strongly negative in their feelings about mathematics. Most felt they should take responsibility for their own learning, try things out for themselves and work with others, suggesting a constructivist view of learning. However, many held onto traditional didactic views; over a third considered learning to be about transferring knowledge from the teacher to the student, regarded the direct teaching of mathematical facts and procedures to be important, and believed completing lots of practice examples helped them to learn.

Recalling their mathematics lessons, the majority experienced didactic teaching involving explanations and examples on the board followed by independent work from textbooks. More than 50% found mathematics difficult and frustrating, and reported feelings of dislike and fear and lack of confidence in their ability. Most students expressed a desire to make mathematics' learning fun, interesting and enjoyable for children. Nell's comments sum up this majority view.

> 'The teacher at school was very uninspiring and this turned me off the subject... I would like to make maths exciting for pupils and encourage children to learn and enjoy the subject by using different and exciting methods' (FG 1:2 09/04).

Individual profiles of the sample group were drawn up from their responses to these questionnaires, providing an overview of their beliefs and attitudes about mathematics and mathematics teaching *(App. 10)*.

The majority of these students had a huge challenge ahead if they were to overcome their initial negative feelings about mathematics otherwise, as Carre and Ernest (1993) warn, they were likely to transmit their fear and dislike of mathematics and lack of confidence to pupils through their own teaching. Equally, those who had enjoyed mathematics and found it interesting and motivating were likely to share this enthusiasm with pupils. Pajares (1992) also observed that students' own experiences play a powerful part in determining how they see their role as teachers and they were likely to emulate the approach that they experienced themselves. For the majority of these students, this was a didactic, transmission of knowledge approach. University sessions therefore focused on building students' confidence and enjoyment and developing their subject and pedagogic knowledge.

A shared understanding of interactive teaching

Exploration of interactive teaching, and students' developing understanding and interpretation of this approach in mathematics teaching and learning, aimed to address some key findings in Moyles *et al's* study (2003). Their evidence suggested that if teachers were to 'develop and apply a full range of interactive practices… *(they)* need opportunities to explore and challenge:

- Their own attitudes to curriculum and pedagogy;
- Implicit and explicit principles that drive practice;
- Explicit educational theory and public knowledge;

- Implicit personal knowledge that underpins their principles;
- The methods and strategies that will allow them to apply these principles;
- Their own instrumental interests in strategies, methods and tactics;
- The conditions that mediate the application of these practices in the classroom' (Moyles *et al* 2003, p.182).

It seemed important that, if they were to understand and implement interactive practices themselves, student teachers should be provided with similar opportunities.

Bransford *et al* (2000) suggest that novices find it difficult to see the deeper connections or relevance of new learning, as they tend to take a surface level view rather than examining deeper meanings. Encouraging students to take conscious control of their learning; identifying the knowledge they have and the knowledge they need and monitoring their further learning, was essential in moving them on from this surface view.

According to Shulman (1986) to become experts teachers need to develop competency in three knowledge domains:

- content knowledge (an understanding of the concepts embedded within the domain being taught)
- pedagogical content knowledge (the forms of representation of those concepts and ways to explain, present and demonstrate these so that they are comprehensible to others)
- pedagogical knowledge (the skills necessary for classroom guidance, incorporating management and communication strategies, and assessment of pupils' learning)

The university sessions aimed to address these three domains, including the NNS promotion of direct, interactive whole-class teaching as weakness in any of these knowledge areas was likely to undermine students' confidence and authority in the classroom.

Adopting a constructivist perspective, students were supported in building their own knowledge and understanding of mathematics, with learning scaffolded through questioning, collaborative group work and discussion. As Richardson (1997) suggests, 'teacher educators must be able to teach in a manner that models the attitudes and behaviours that they would like their preservice teachers to manifest in future classrooms' (p.35).

Features of interactive teaching

The key features of interactive teaching pertinent to this study emerged from discussions with students in university sessions. As Moyles *et al's* (2003) study found, most teachers were uncertain about what interactive teaching was and it was important to establish a shared understanding between students before they attempted to put interactive teaching into practice. These features then provided the focus for later observations of their teaching.

Groups used concept mapping to explore features of interactive teaching *(App. 12)*, and these showed common elements across all groups, echoing Lave and Wenger's (1991) observation that 'ways of doing and approaching things ... are shared to some significant extent among members' in communities of practice (Smith 2003 p.3). After analysing the data, pupils' active involvement (practical activities), questioning, discussion, and creative problem solving/investigation were agreed with students to be four key features they shared.

Features of Interactive Teaching

Features	Description
• **Pupils' active involvement (practical activities)**	Use of practical, 'hands-on' activities that actively engage pupils.
• **Questioning**	Use of 'open' and 'closed', 'higher' and 'lower order' questions.
• **Facilitating discussion**	Use of teacher/pupil and pupil/pupil discussion
• **Creative problem solving/investigation**	Working collaboratively. Use of investigative and creative problem solving activities/ exploring new ideas

This table shows key features of interactive teaching. The second column further explains these features.

Pupils' active involvement in practical tasks was foremost in most group discussions. This focus on 'practical engagement/activities' emanated from discussions during sessions where students translated the NSS demand for pupils' 'active engagement' as using practical equipment and 'doing things themselves', relating this to the constructivist view of learning through experience. Orton and Frobisher (1996) had similarly noted this tendency for practical work to be linked to a constructivist view of learning,

> 'Although constructivism does not advocate the use of practical work in which children handle and manipulate concrete materials, there is a long history to the commending of the use of 'manipulatives', from the time of Froebel, through Stern, Cuisenaire and Dienes, to today, and there are many who would expect a constructivist classroom to contain a wealth of manipulative materials' (p.19).

Being easy to recognise in teaching, many references were made to this aspect in the students' observations of teachers, reflecting McIntyre's (1988) concern that when observing experienced teachers, students tend to focus on the surface or observable features.

Students' initial observations of Interactive Teaching

Students' observations of experienced teachers indicated that some aspects of interactive teaching were happening infrequently. Pupil/pupil discussion was rarely reported and collaborative, creative problem-solving not observed at all, although some students commented on the use of worded number problems from SATs papers. Practical materials were widely used, particularly in the oral, mental starter where games and quizzes, along with number fans, number cards, counting sticks and mini-whiteboards were noted.

A summary of these observations *(App.6)* indicate a focus on worksheets, drill and practice and closed questions with limited use of open questions or creative investigative activities. As one student remarked, what she saw was similar to her own experience as a pupil; 'lots of chanting of tables, you know, learning by rote... it was just loads of worksheets all the time – I wasn't expecting that after what we've been doing here' (field notes, sess. 4, 10/04).

Already they were experiencing a dissonance between theory, ideas espoused in university sessions, and practice observed in schools, finding little real change from their own school days, except perhaps in the use of more practical activities and manipulatives. This raised the question of whether they would attempt to implement an interactive approach themselves or, as Carre and Ernest (1993) suggested, would adopt a more familiar didactic approach, particularly if this was the approach modelled by their classteachers.